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Solid Waste Handling and Disposal in Multistory Buildings and Hospitals

ESCO/Greenleaf

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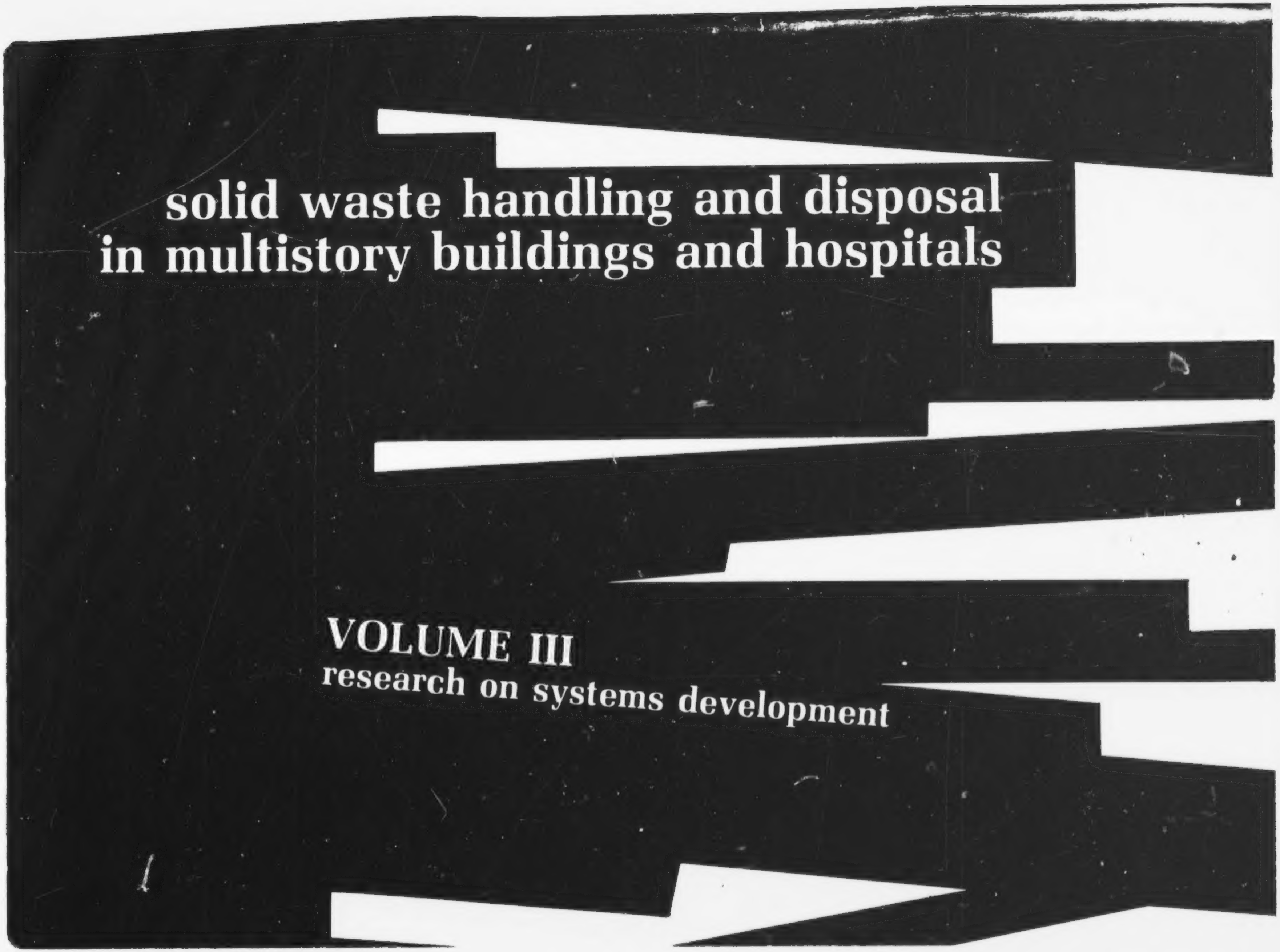

solid waste handling and disposal in multistory buildings and hospitals

VOLUME III

research on systems development

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A study of solid waste handling, storage, processing, and disposal systems and practices in multistory buildings, hospitals, and detention facilities. The complete study is reported in four volumes. Volume I presents a digest of study objectives, development of systems evaluation methodology, and criteria for systems design, together with a brief review of the total study. Volume II is a detailed study and evaluation of systems and practices in fifteen County-owned building complexes. This volume covers an investigation and evaluation of available solid waste handling, storage, processing, and disposal equipment and systems adaptable to building installations. This report provides coverage on both marketed systems and equipment components, as well as systems concepts in the development and "idea" stage. Volume IV provides an extended evaluation of systems adaptable to the various classifications of buildings and complexes considered in the study, with recommendations for operational improvements or modifications of existing systems as may be required in each type of facility.

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VOLUME III research on systems development

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VOLUME I	*Summary, Conclusions, and Recommendations* (SW-34d.1) is available under separate cover from the U.S. Government Printing Office.
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FOREWORD

In the past century of national growth, reflected in increased population, expanding municipalities, and greater industrial and commercial enterprises, this Nation responded with nonconcern to a concurrent physical deterioration of the country. The first comprehensive water pollution control legislation was not enacted until 1956; the first comprehensive air pollution legislation, in 1963: Finally, six years ago, legislation acknowledged a national solid waste problem--a pollution that can pervade the air, water, and land.

Under the Solid Waste Disposal Act of 1965 (Title II, P.L. 89-272) and now under the broader mandate of the Resource Recovery Act of 1970 (P.L. 91-512), municipalities and other agencies are eligible to apply for Federal demonstration grants to study, test, and demonstrate techniques which advance the state of the art in the solid waste management field.

Disquieting statistics compiled by the U.S. Environmental Protection Agency point up the significance of these solid waste management demonstration projects. The Nation's outlay for getting rid of its debris is $4.5 billion annually--and growing. Most of this cost is: (1) for collecting only part (180 million tons) of the 360 million tons of household, commercial, and industrial waste actually being generated; (2) for disposing of it in dumps or landfills (94 percent of which are unsatisfactory) or in incinerators (75 percent of which are inadequate). One basic Federal policy has been to encourage the concept of areawide solid waste management as a sound vehicle for raising the overall level of these sanitation services to safeguard environment and public comfort.

The County of Los Angeles received one of these demonstration grants, to make an in-depth study of solid waste handling and disposal in multistory buildings and hospitals. The results are reported herein.*

--SAMUEL HALE, JR.
Deputy Assistant Administrator
for Solid Waste Management

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*For studies also related to collection and disposal of solid wastes in high-rise buildings, refer to National Academy of Sciences--National Research Council. Collection, reduction, and disposal of solid waste in high-rise multifamily dwellings. Rockville, Md., U.S. Environmental Protection Agency, 1971. [Distributed by National Technical Information Service, Springfield, Va., as PB 198 623. 169p.]

ACKNOWLEDGMENT

The ultimate purpose of this study is to determine improved solid waste handling and disposal techniques adaptable to various types of multistory buildings, hospitals and detention facilities. This research initiated by the Project Planning and Pollution Control Division, Department of County Engineer, County of Los Angeles, was performed with the assistance of the Solid Wastes Program, National Center for Urban and Industrial Health, U.S. Public Health Service, Department of Health, Education and Welfare,* and through guidance of the Advisory Committee on Solid Wastes, organized by the Department of County Engineer to assist the project team throughout the study period.

ESCO-GREENLEAF, A Joint Venture (Engineering Service Corporation, Los Angeles, California, and Greenleaf/Telesca, Engineers & Architects, Miami, Florida) was selected by the Board of Supervisors to conduct this study in collaboration with the Project Planning and Pollution Control Division. Special consultants assisting the project staff in certain aspects of the study include Elmer R. Kaiser, Senior Research Scientist, New York University; George S. Michaelsen, Professor and Director, Division of Environmental Health and Safety, University of Minnesota; Richard G. Bond, Professor, School of Public Health, University of Minnesota; Donald Vesley, Assistant Professor, School of Public Health, University of Minnesota; and Gordon P. Larson, Air Pollution Control Consultant, Philadelphia, Pennsylvania.

Considerable interest in this study has been shown by many governmental agencies, equipment manufacturers and individuals directly concerned with the subject. With this encouragement, together with the direct and indirect assistance of numerous contributors, enthusiasm for successful completion of the study has been maintained.

Sincere appreciation is extended to the administrators and staffs of all hospitals, members of the Sheriff's Department and representatives of the Department of Building Services, who cooperated and assisted in the on-site investigations in those buildings under their respective jurisdictions.

The constructive criticism and guidance of members of the Advisory Committee on Solid Wastes were invaluable and special recognition for the member agencies is warranted. Agencies represented in this Committee include: Los Angeles County, Hospital Department, Mechanical Department, Building Services, Health Department, Forester and Fire Warden, Department of County Engineer, and Air Pollution Control District; and the State of California, Department of Public Health and Regional Water Quality Control Board.

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* Now the Office of Solid Waste Management Programs, U.S. Environmental Protection Agency.

PREFACE

Problems of solid waste collection and disposal in institutions and other multistory buildings mirror many of the same problems confronting the community at large--in greatly magnified form. In large building complexes, as in many of the Nation's communities, solid waste systems often are so crude as to be termed, in the words of this report, "man-handling." Either in large buildings, the subject here, or in a community, a two-prong approach will be necessary--immediate application of improved methods that are presently available, and then planning and research for optimal future solutions.

This study, supported in part by solid waste management demonstration grant no. G06-EC-00164 from the Environmental Protection Agency, reflects this approach, and hopefully will motivate administrators and designers concerned with multistory complexes to consider solid waste handling and disposal as an integral factor in the total service system provided for these buildings. Such a consideration must take into account safety, sanitation, convenience, and cost. The complete study is reported in four volumes:

Volume I, Summary, Conclusions, and Recommendations, presents a digest of study objectives, development of systems evaluation methodology, and criteria for systems design, together with a brief review of the total study. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

Volume II, Observations of Local Practices, is a detailed study and evaluation of systems and practices in fifteen County-owned building complexes, including seven hospitals, four multistory office buildings, and four detention facilities, varying in function and size within each classification. This report establishes the theoretical standards of operation peculiar to each plant and, through field observations, actual operating conditions of these systems. Available from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia 22151.

Volume III, Research on Systems Development, covers an investigation and evaluation of available solid waste handling, storage, processing, and disposal equipment and systems adaptable to building installations. This report provides coverage on both marketed systems and equipment components, as well as systems concepts in the development and "idea" stage. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

Volume IV, Selection and Design of Solid Waste Systems, provides an extended evaluation of systems adaptable to the various classifications of buildings and complexes considered in the study, with recommendations for operational improvements or modifications of existing systems as may be required in each type of facility. Design criteria and preliminary design of systems modifications, together with outline specifications and cost estimates covering installation and operation, are developed on a selected building complex. Available from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia 22151.

John A. Lambie, County Engineer, County of Los Angeles, was the project director for this study; Peter M. McGarry, with our Division of Demonstration Operations, was the project officer.

--JOHN T. TALTY, *Director*
Division of Demonstration Operations
Office of Solid Waste Management Programs

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Observations of present day methods, practices and equipment used in the movement of solid waste material in modern multistory buildings reveal little indication of widespread change or progress since the first concepts of multistory construction. The in-building handling system relying on pushcarts and portable bins for horizontal movement, and conventional gravity chutes, elevators or stairs for vertical movement, still prevails.

Special purpose buildings with complex material handling functions, such as hospitals, until the present time, have also largely operated with similar systems. Continuing expansions and improvements in hospital plants, together with the ever increasing costs of operation and added emphasis on environmental conditions, have provided the impetus for research and development of equipment to simplify the flow of both incoming supplies, as well as outgoing wastes generated from their use. The transfer of waste materials from point of generation to the point of on-site disposal or central storage is the greatest and most costly task within building waste systems. Although the ultimate disposal of these materials is often looked upon as the function that potentially has the greatest effect on the general public and the community environment, it is the least costly increment of the total solid waste system and the lesser concern of in-plant solid waste management. Improvements to the waste system must consider all aspects of solid waste management. This applies to all building types.

The emphasis today in research and development is not isolated to any single component or function of the waste system. Conversely, efforts are being directed towards development of equipment that will serve all areas of the system, including transfer of waste materials by means of automated conveyors, special containerization, and improved processing and disposal methods. Consultants, together with manufacturers, are exploring the "closed system" concept, utilizing various combinations of material handling, storage, processing and/or disposal equipment which will provide systems minimizing or eliminating manual handling of waste materials after the initial deposit.

The purpose of this study is to investigate and establish the total requirements of solid waste systems serving multistory buildings, hospitals and detention facilities, and recommend improvements or modifications of existing systems that will provide an acceptable level of operation, environmentally and economically.

The preceding volumes have provided a digest of the overall study objectives, a summary of the total study, and the detailed study and evaluation of existing waste systems in selected building complexes in Los Angeles County where waste system improvements are being considered. In order that the reader be informed further on the total background of this study, review of Volumes I and II are recommended.

Purpose of this Division of Study:

The purpose of this division of study as contained herein is (1) to review the equipment that is presently marketed and available for use in solid waste systems in multistory buildings, hospitals and detention facilities, (2) to investigate equipment that is in the developing stage, (3) to identify new system concepts that are being considered in this field, and (4) to evaluate equipment usage for specific applications in various types of special purpose buildings.

This equipment review is primarily intended to provide necessary data for upgrading the waste systems in the local building complexes under study and similar use to others in the industry. It is to be hoped that the information gathered herein will have a longer useful life than that to be normally expected from a study of this type. The compiled data could prove useful in the conceptual planning stages of many types of buildings yet to be designed and built.

This compendium gathers together much useful information. It is far from a complete treatise on the subjects, but it is believed to provide some specific direction toward the solutions to many complex problems, not only limited to solid waste systems but on the much broader base of total material handling systems for the distribution of general supplies as well.

Method of Research and Investigation:

Observations of the basic requirements of solid waste systems of special purpose buildings were accomplished through (1) inspection of selected plants and their respective practices in various geographic locations, (2) literature review and, (3) consultation with knowledgeable parties in plant administrative, management and operational capacities.

Research and investigation of equipment and systems were performed through:

(1) Review of trade journals and technical publications.

(2) Attendance at trade shows and technical sessions.

(3) Review of manufacturers' data sheets and informational releases.

(4) Inspection of marketed equipment and prototypes at manufacturing plants.

(5) Inspection of actual working installations of equipment in hospitals, apartment complexes, office buildings, commercial buildings, warehouses, etc.

(6) Discussions with engineering and marketing representatives of manufacturers.

(7) Consultation with qualified authorities in fields related to the general subject.

The experiences and opinions of technicians and other personnel involved in the operation of solid waste systems and general material handling systems have been sought and listened to during field inspections. These inspections have included such outstanding examples of modern handling systems as the installations at Loyola University Medical Center at Maywood, Illinois, and Mercy Hospital and Medical Center at Chicago, Illinois.

It is not possible to investigate, or even to list, all of the many manufacturers of useable equipment in the very broad field of solid wastes. For this reason, a list of reference materials and information sources is included in the Appendix, in addition to the particular equipment and methods discussed in this section of the report.

General Background:

A brief review of pertinent definitions presented in earlier volumes may be of later assistance to the reader in understanding the contents covered herein. Initial investigations as conducted earlier in this study (Volumes I and II) identified the four basic components or sub-systems in solid waste systems in multistory building complexes as the Unit, Inter-Unit, Inter-Building and Off-Site systems, and further identified the four basic functions that may be performed within each of these sub-systems, i.e. handling, storage, processing and disposal.

Within the concept of this study, handling functions and related terms include collection, horizontal transport, vertical transport and discharge of solid wastes, or distribution of other materials from a point of origin to an ultimate destination. Such movement or handling is considered to terminate at the boundaries of building complexes, but in some instances may include off-site movement.

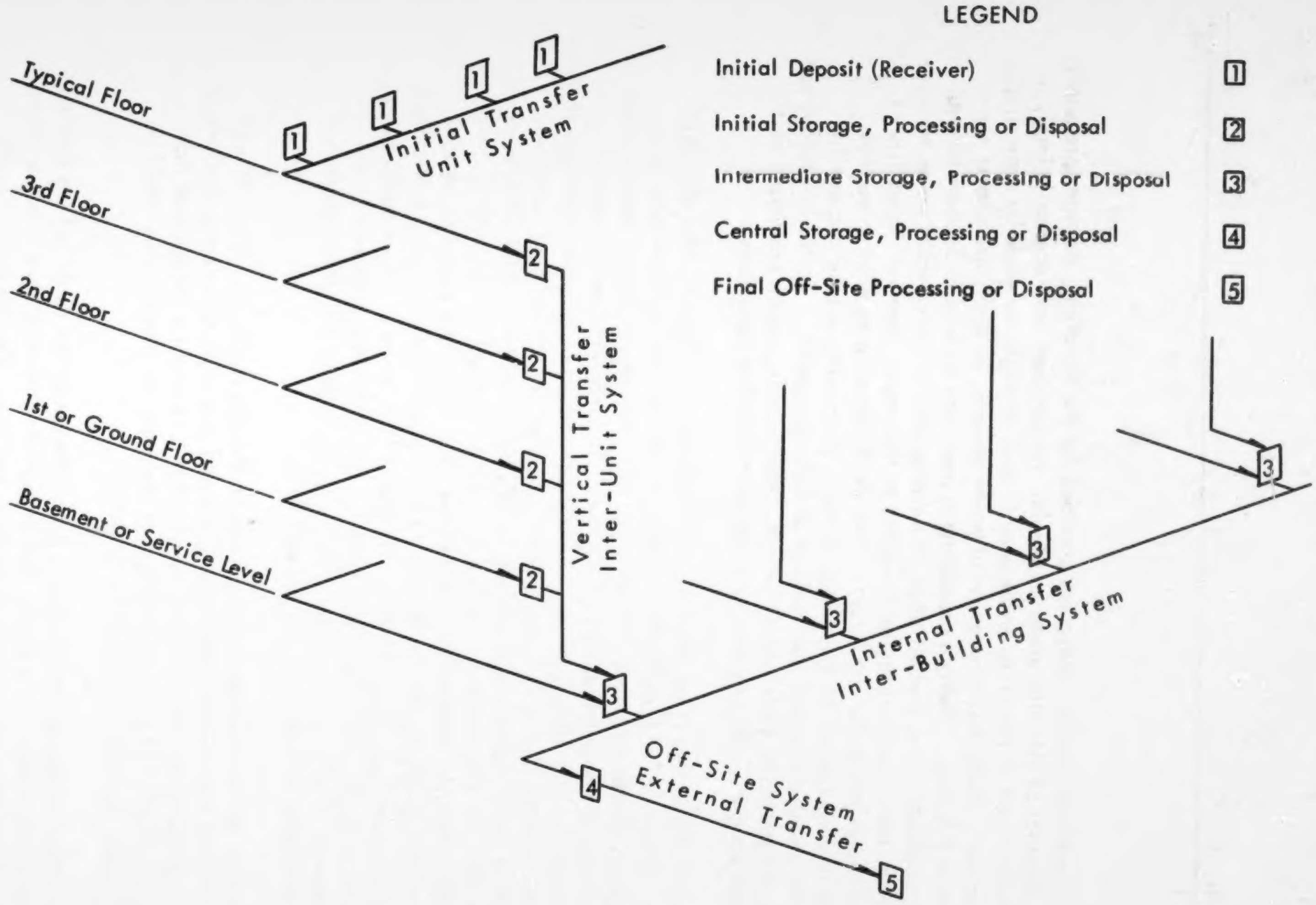
The storage of wastes is defined as the interim containment of accumulated materials in either loose, compacted or other processed form prior to subsequent handling, reprocessing or disposal.

Waste processing is considered as those preparation functions, such as bagging or encapsulating of disposables and reusables, as well as treatment to disposables involving volume reduction through changes in size, shape, uniformity or consistency. Waste processing may also include those techniques employed in reconditioning reusables such as laundry, bottlewashing, autoclaving, etc. However, the scope of this study in the case of reusables shall be limited to the interim storage and handling of these materials up to the point of central storage and reprocessing.

Waste disposal is considered within this report as the terminal treatment of waste materials. This ultimate treatment is limited to various disposal processes or combinations of processes involving natural or accelerated conversion of the raw wastes into useful or innocuous products.

Figure I-1 schematically illustrates the location and identifies these components or sub-systems and functions that will be found in solid waste systems in multi-story building complexes.

The term "solid waste system", as used in this report, is defined as a combi-


LEGEND
Initial Deposit (Receiver) 1
Initial Storage, Processing or Disposal 2
Intermediate Storage, Processing or Disposal 3
Central Storage, Processing or Disposal 4
Final Off-Site Processing or Disposal 5
Typical Floor
3rd Floor
2nd Floor
1st or Ground Floor
Basement or Service Level
1
1
1
1
Initial Transfer
Unit System
2
2
2
2
Vertical Transfer
Inter-Unit System
3
3
3
3
Internal Transfer
Inter-Building System
4
Off-Site System
External Transfer
5

SCHEMATIC OF TYPICAL SOLID WASTE SYSTEM IN A MULTISTORY BUILDING COMPLEX FIGURE I-1 nation of methods and/or equipment provided for the handling, storage, processing and/or disposal of all solid waste materials. Its use does not necessarily imply a fully mechanized or complete arrangement, such as might be made by some single manufacturer. Fully mechanized solid waste systems, as such, are almost non-existent at this time. Today's prevailing systems can be said to be more manual than mechanical. The present stage of development in which solid waste management finds itself, particularly as it relates to this study, demands flexibility of thought and planning for the future. This should involve combining various methods and equipment for handling, storage, processing and/or disposal in efforts to produce a system mechanized as fully as possible. Partially mechanized systems are presently under development. Additionally, some prototypes exist but these have not had exposure to extensive operating conditions.

The timeliness of this study demands some discussion. Many months of investigation, numerous field observations and countless interviews convince us that this report is being prepared at a time just prior to very important developments in the fields of waste handling and disposal. It is regrettable but true that several new handling methods and treatment processes have been or are presently being developed, but which are, as yet, untested under working conditions. Certain of these methods and equipment will be discussed in later sections of this report. In some cases, no specific recommendations can be made. This condition and some limitations are imposed upon us for two principal reasons. Some of the equipment known to exist is of foreign origin and not yet installed or proven under operating conditions in the United States. Other equipment or methods, some of which have been seen by the consultant, are still in the development or pilot plant stages and the sponsors have placed restrictions upon disclosure of details at the present time.

The rate at which progress is being made in the development and use of more sophisticated methods of handling and disposal may well make some portions of this report outdated almost before publication. It must be recognized that during any period of great technological progress, no precise time could be totally ideal for such a study to be made.

None of the foregoing remarks imply any criticism of the timing of the commissioning of this study. It is likely that an earlier time may have been too soon, while a later date may possibly have been too late. On the contrary, the imperativeness of the need for further expansion and continued updating of the study is stressed.

The current upsurge of new concepts and developments of solid waste management equipment is due largely to expanded and justifiable concern with environmental pollution. Air, water and land pollution are matters which demand immediate, and in certain areas, drastic steps. The urgency of some of these problems has fostered increased interest in possible solutions. Industries, some of which were not formerly associated with solid waste management, have released funds for research and development of new or improved methods of coping with the pressing problems. While some of the newest of these concepts are not yet proven, it is apparent that great forward strides are being made.

Another and very important factor which has stimulated equipment development is the tremendous increase in the volume of items which are prepackaged and articles which are designed to be disposable. This increased volume, plus the changed nature and mix of materials now found in refuse, have combined to make improvement and changes in disposal methods mandatory.

The meaning of "disposable" has changed to a noticeable extent, as applied to solid waste management problems. This is especially true if Webster's definition, "easy to get rid of", is used. Many of today's plastic "disposables" almost defy destruction. Certainly many of them cannot be adequately disposed of by presently used conventional processes and equipment. Some of these articles, commonly used today, are disposable only in the sense that they are designed for one-time use only. Container manufacturers and packaging designers have flooded the merchandising market with these "undisposable" disposables and, with very few exceptions, without having first determined whether or not the leftover package or container is destructible by conventional means.

The volumes of these various so-called disposables are now increasing at alarming rates, especially in hospitals. Various kinds of instruments, containers and linens are but a few of the items which will have but one use and then be discarded. These supplies are already seen in some institutions and the apparent trend indicates continuing increase in use in the future.

Other items which now have one use before being discarded include containers made of steel, aluminum, glass and paper, as well as various types of plastics. Storage space for reusables, need for sanitizing after use, and, very importantly, the labor cost of separate handling and processing have made the disposable articles on the surface almost an economic necessity. Added to this is the convenience factor and when these several plus-features are considered, their increasing use is all but guaranteed.

The growth of the demand for prepackaged merchandise; the proliferation of the use of disposable containers; the very widespread use of plastics, many types and forms of which are highly resistant to present disposal methods; growing awareness of the hazards of environmental pollution, and the resulting restrictions placed upon the burning of wastes have combined to bring about interesting and desirable research and development in processing and disposal methods. Substantial sums are being expended by private enterprises for experimentation and the construction and operation of pilot plants which are designed to improve waste processing and disposal.

Organization of Material:

In the early stages of this investigation, it was anticipated that classifications and definitions of the various types of equipment encountered was requisite to the study, both for the readers' benefit and as a working tool in preparation of the report. The major classifications or divisions of equipment were limited to correspond to the four basic functions of the waste system, i.e. handling, storage, processing and disposal.

The sections of this report devoted to the narrative review of this equipment also follow these classifications. In support of this equipment review within each major classification, referenced appendices were prepared, identifying (sub-classification) by name and definition, the individual equipment components and accessories. Separate appendices (Product Lists) were also prepared, listing these equipment components alphabetically and identifying respective manufacturers and known trade names. To complete the appendices in support of this equipment review, a master alphabetical index of these manufacturers, with addresses, was prepared.

The criteria for the selected classification and sub-classification of equipment components was based on functions performed by the equipment and the mechanical characteristics in the design of each. These established classifications, sub-classifications and definitions relate only to this report for the purpose of grouping like items, and will not necessarily agree with manufacturers' nomenclature, where wide variations of names and terms were encountered. The need for eventually standardizing equipment terminology by manufacturers serving the solid waste industry for the benefit of users of this equipment cannot be over-emphasized.

In the review of equipment, the inclusion of detailed descriptions of products of particular manufacturers or the omission thereof constitutes or implies neither approval nor disapproval, acceptance nor rejection, endorsement nor the lack thereof, on the part of the consultant. Every effort has been made to describe representative makes of equipment and such descriptions are included for general informational purposes only.

The listing of manufacturers of various products identified in this report is only partial. To identify every manufacturer producing equipment related to the subject is neither practicable considering the time limitations imposed, nor necessarily useful for purposes of this report. There are many lists published covering specific types of equipment, such as those to be found in Material Handling Engineering Handbook & Directory; Solid Wastes Management Sanitation Industry Yearbook; Guide Issue, Journal of the American Hospital Association, as well as many other sources. In general, product listings have been restricted to those items which have been seen at trade shows, or inspected in operation, or on which descriptive printed matter has been reviewed. Numerous equipment manufacturers failed to respond to inquiries and hence are not included.

During the course of this investigation, voluminous project records, consisting of equipment catalog files, inspection reports and correspondence with numerous manufacturers, were developed. This written review in a sense represents only a summary of the total activities undertaken.

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Body, Truck, Special II-7
Cart, Electric, Driverless, Self-powered II-7
Chute, Gravity II-14
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The major task and cost in the operation of solid waste systems is the movement of waste material between the initial point of accumulation and the ultimate disposal point. In effect, operation of solid waste systems is largely a material handling function, adaptable to mechanization but predominantly performed today by manual methods. Today's manual systems are largely "built-in" by building design conditions. It is not uncommon to find, even in contemporary designs, numerous interim waste storage points for the temporary deposit of wastes, thereby breaking the cycle of movement and thus creating a number of rehandlings of the same material before reaching the final destination point. Today, scarcity of labor for this type of work, the trend of lower productivity of labor, as well as rising labor rates, collectively emphasize the need for mechanization of the more complex systems.

Unfortunately, far too much of the solid wastes, as well as supplies in institutions, are "handled" and "rehandled" instead of being directly transported by mechanical means. These conditions have been permitted to develop by institutional and industrial planners and management. Institutional management, habitually satisfied to "do it by hand", ignored the development of these plant engineering needs, planners were not aware of these needs, and the materials handling industry was not properly alert to a new market. The latter was apparent during the course of this investigation when it was found that many equipment manufacturers were unaware of the needs in the field of solid waste handling at the time they were first contacted. Due to this, it was equally apparent early in the investigation that developing information on waste handling methods and equipment would be more time-consuming and involved than would be that required for storage, processing and disposal methods. Considerable time and effort was made in contacting manufacturers and as a result of many otherwise unproductive inquiries, it is indicated that some companies have been prompted to investigate the material handling problems in solid wastes. Hopefully, new contributions in useable equipment will be forthcoming for this field.

The apparent reluctance on the part of some manufacturers to become involved in waste handling is somewhat understandable. In general, the subject of materials handling has long been almost solely associated with industry. Applications of their methods and equipment in the past have been primarily directed to warehousing, processing and manufacturing industries, where identical, or at least similar, articles are handled. If the material is in bulk, it normally has consistency in shape and other physical characteristics throughout its volume and, hence, mechanical handling is not too difficult to develop. On the other hand, solid wastes, especially those generated in hospitals, almost defy description. This material lacks uniformity of size and shape. It is a non-homogeneous mix and may be highly contaminated. Adapting a mechanical handling system to these conditions may be highly complex.

The relationship of the movement of "clean" and "dirty" materials within a building complex is an involved process. In effort to simplify the relationship of this process, Figure II-1 schematically shows the supply-waste cycle. This diagram is admittedly an oversimplification but serves to emphasize the parallel course in movement of supplies and wastes and the basic activities between the point of supply, point of use (or conversion to waste), and ultimate point of disposal. Locations of these activities (storage and processing) for both supplies and wastes may be and generally are interspersed throughout the system. The point is that planned material handling systems can minimize the interim storage needs and permit efficient direct and uninterrupted flow of both materials.

It is essential that the reader be made aware of the current state-of-the-art as it applies to solid waste handling. Considering the existing need, it is inadequate. While some advancement is being made, these efforts range from meager to sophisticated. However, if one thinks of general materials handling, as opposed to the handling of solid wastes, then giant strides have been made. Electronically controlled, fully automated supply systems are available, but they are neither presently suitable for specialized use in handling solid wastes nor economically feasible for this purpose alone. Types of equipment, such as overhead chain conveyors, horizontal or inclined belt conveyors, or perhaps long roller conveyors as used in industry, do not at first glance seem to be applicable to the problems encountered in solid waste handling. Although perhaps not directly useable, it is possible that these basic methods of moving materials might be modified to meet the needs under study.

With few exceptions, little has been seen which could be described as complete

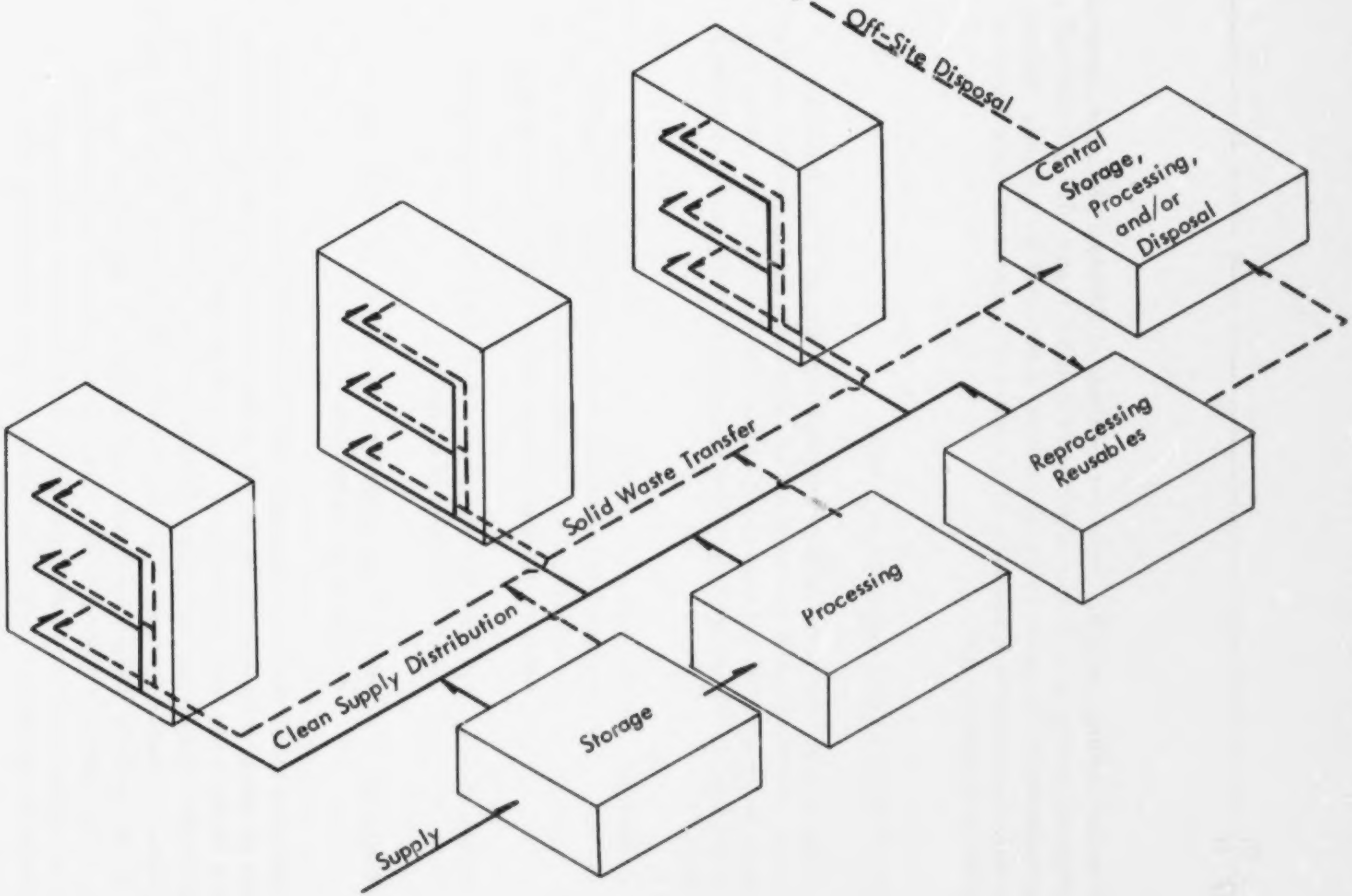

Off-Site Disposal
Central Storage, Processing, and/or Disposal
Reprocessing Reusables
Solid Waste Transfer
Processing
Clean Supply Distribution
Storage
Supply

FIGURE II-1 SUPPLY-WASTE CYCLE IN A TYPICAL MULTISTORY BUILDING COMPLEX

solid waste handling systems. There are hundreds of different pieces of equipment designed and produced to handle or transport material items. These individually are considered in this report as equipment components and not systems. Most of the installations seen have consisted of a number of components rather than a complete integrated system.

Review of Handling Methods and Equipment:

As defined earlier, the term "waste handling" includes all those functions associated with the transfer or movement of solid waste materials after creation, excluding storage and actual processing and/or ultimate disposal methods that may be employed. These waste handling functions are limited to and defined as follows:

collection - Methods and equipment used in (1) the pickup of accumulated wastes from the initial point of deposit or subsequent storage points and (2) loading of vehicles or other means of conveyance for transport.

transport - Methods and equipment used in the vertical or horizontal movement of materials.

discharge - Methods and equipment used to unload wastes from the carrier or transporter.

The most elementary and, at the present time, the most widely used class of horizontal transport devices in use for the horizontal transport of solid wastes in institutions is the hand-pushed cart. This indispensable piece of equipment comes in many shapes and styles; is available in metal, fiber and plastic; and of standard or special designs. Carts are available from simple open-top canvas hampers to specially designed stainless steel bodies. A very wide range of types of conveyors, including roller, belt, chain, monorail and pneumatic tube, plus many varieties of these principal classifications, may also be considered in the general class of horizontal transport equipment. For off-site operations and for some possible on-site transport requirements, special types of collection vehicles or mobile packers or transfer trailers may be employed.

Gravity and vacuum chutes alone are the only equipment items specifically designed and commonly used for the vertical transport of wastes. The principal forms of multipurpose vertical transport are elevators, dumbwaiters or specially designed lift systems, which will accommodate only carriers or transporters of a special type and handle all types of material. Controls may be manual, i.e. they can be summoned or dispatched by push buttons or they may be automated to sequence with loading from or unloading to horizontal conveyors.

Some devices, such as pneumatic tubes, gravity chutes, certain types of conveyors, and other equipment, provide multiple functions. They not only transport materials but may be used to load or discharge bulk or containerized items, and may incorporate interim storage or holding stations for en route materials. These may be complete horizontal and vertical transport systems designed and installed by one manufacturer or they may be combinations of loading devices, horizontal and vertical conveyors and discharging equipment of different manufacture, which have been combined into an integrated system.

Such devices as blowers or suction fans, cyclonic separators, pneumatic tubes, various types of conveyors, vertical lifts, pipelines for slurries, and other equipment can be arranged to operate as an integrated handling system. Some of the most interesting general materials handling systems observed have been examples of good engineering and the apparent successful "marriage" of components made by different manufacturers.

The most sophisticated, fully automated systems were designed and largely built and installed by single manufacturers. These combine horizontal and vertical transport elements, using special track, transporters, modules and electronic controls. Units can be summoned and dispatched from control panels and operated within the system, unattended.

The review of equipment as contained herein covers the limited field of specialized equipment for handling solid wastes as well as certain general materials handling equipment and accessories considered to be adaptable for possible use in solid waste systems.

Classification of this equipment involved reconciling the wide variations of names and terms used by manufacturers and the material handling industry at large, as well as in solid waste management. For purposes of this report, these equipment classifications were established by definition, as appear in Appendix "A". A product list, Appendix "B", was also prepared providing an alphabetical listing of the equipment classifications, together with a partial listing of the respective manufacturers and trade names.

The intent of Appendix "A" is to identify by definition all equipment components which might be unknown to the reader or where some degree of confusion would be created if the items were not defined. The product list, Appendix "B", includes all equipment classifications as defined, as well as other equipment items and accessories where names are self-explanatory.

The following narrative review of equipment covers selected categories of equipment with descriptions of mechanical and operational characteristics and in most cases discussions on particular application (or possible application) in the waste handling system.

Body, Truck, Special:

Among various special designs of truck bodies available for application in the waste systems of institutional complexes are those produced by Bynal Products Inc. and Hanna Enterprises.

("Hussler" - Bynal Products, Inc.)

The "Hussler" body is made by Bynal Products, Inc. in six and eight cubic yard sizes. They can be mounted on small chassis, having relatively short wheel bases, and can be used in cramped areas which could not be serviced by larger vehicles. They are useful in inter-building service where a vehicle having multipurpose abilities is almost indispensable.

Several features make the "Hussler" unique. The body has 38" high sides, but forward portions on both sides can be dropped to half-height to provide easier side loading. The tailgate, designed to act as a chute for rear unloading, will also operate as a conventional hydraulic tailgate for loading and unloading. A most important feature is a dual hydraulic lifting mechanism which permits the entire body to be lifted vertically in a level position to match dock heights. Additionally, the body can be inclined for rear dumping.

("Trashmobile" - Hanna Enterprises)

Another small and special type body which is practical for use in building complexes is the "Trashmobile". It has small capacity, of about a yard and a half, and can be used as a satellite vehicle, serving larger ones by reason of its ability to reach otherwise inaccessible areas It has a hydraulic dumping mechanism for rear unloading. It is easily operated by one man and can carry a variety of loads. It is designed to be mounted on a Datson, Jeep or International Scout chassis and hence would be highly maneuverable.

Cart, Electric, Driverless, Self-powered:

Properly described, these carts are the hearts of two nearly identical transportation systems which have been recently developed and shown at materials handling and hospital equipment shows around the country. The systems are made and marketed by Jervis B. Webb Company and the Amsco Systems Company, a division of American Sterilizer Company. The Webb vehicles are identified by trade name as "Mini-Carts" and the Amsco units as "Amscar". The Webb organization serves industry generally while Amsco is primarily in the hospital equipment field.

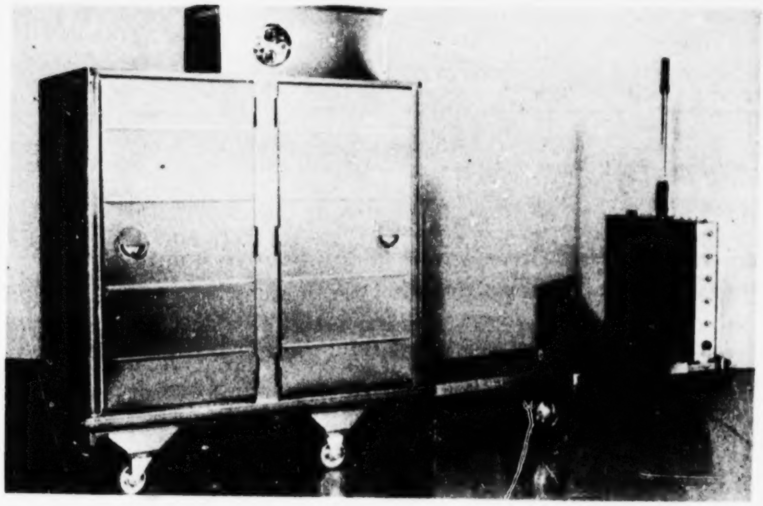
Three hospitals now under construction will be serviced with Webb Mini-Cart systems: The Jewish Hospital at Cincinnati, Ohio, will use a 40-cart system; Elmbrook Hospital, Brookfield, Wisconsin will have 18 carts; and Elliott White Springs Hospital, Lancaster, South Carolina, will have a 16-cart system. The 500 bed Fairfax Hospital at Falls Church, Virginia, will inaugurate its system with 60 Amscar units.

("Amscar" - American Sterilizer Company)

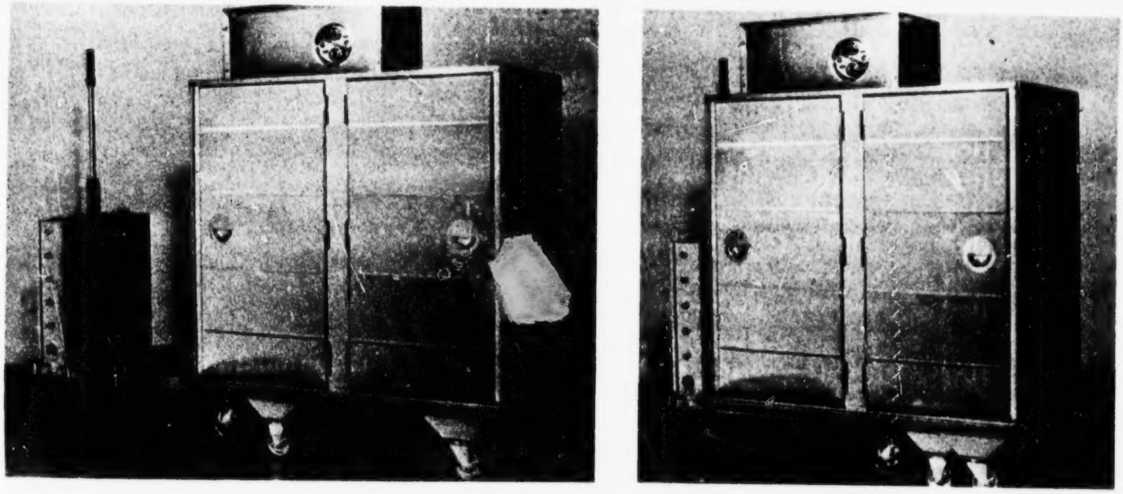
The Mini-Cart and the Amscar are basically the same unit but for purposes of description, reference will be made to Amscar since its primary use is intended to be in hospitals. This vehicle is electric-battery-powered. The batteries are housed under a stainless steel platform floor. It is designed to follow an electronic guidepath of wire concealed in the floor. The front or dashboard of the Amscar houses the programming control devices, together with a steering and control tiller for manually guiding the unit onto or off of the guidepath. Under such manual guidance and utilizing self-contained motive power, the unit can be directed to locations remote from the buried wires.

A variety of containers or modules are available to fit onto the bed or platform of the cart. These can be custom designed but standard models for handling food, linens, general supplies, and soiled items are available.

The vehicle is capable of raising or lowering the various types of wheeled and castered modules with its own power. After the Amscar is guided beneath the module, the vehicle platform is raised sufficiently to lift the wheels of the module clear of the floor. When the cart and module have reached their destination, the module is lowered to the floor and the Amscar withdrawn. After disengagement the module may be rolled to any desired point in the manner of a conventional cart.



a. Amscar Vehicle Approaching Module



b. Process of Mating Has Begun

c. Mating Complete with Module Loaded for Transport

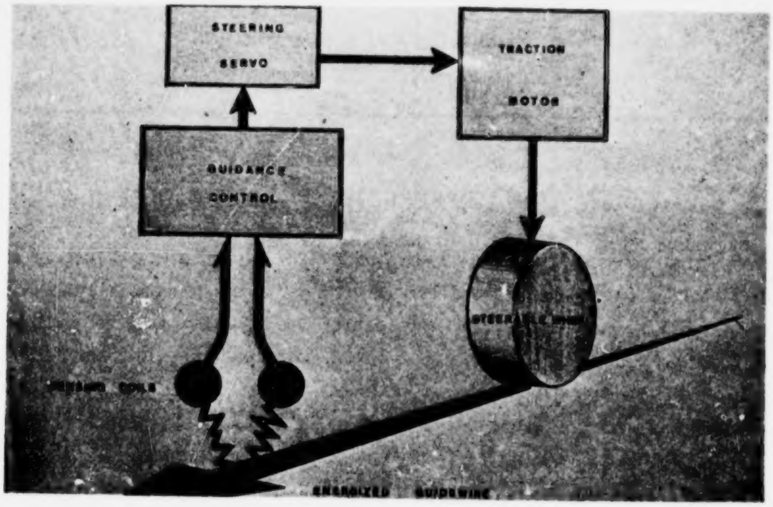
The Amscar is dispatched by means of the pushbutton controls on its own panel. After being placed over the guidepath, the unit proceeds to the programmed destination unattended. Built-in proximity sensors halt the cart if a person or object obstructs its path. A central station for controlling the movement of carts can be provided, as well as a series of control panels located at nursing stations and other strategic points.

Vertical transport of the vehicles and their loads is provided by special elevators designed exclusively for this purpose. These elevators are instructed by the control system. Cars are summoned, shaftway doors opened and closed, vehicles injected, vertical travel accomplished, and carts ejected onto another level, in an entirely automatic sequence.

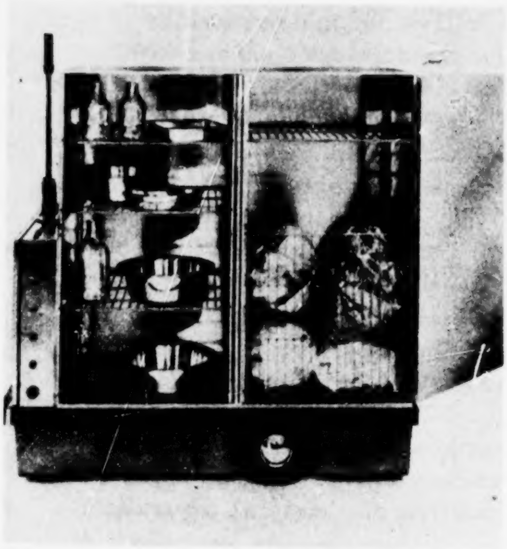
A special feature of the Amscar system is a central cart cleaning and sterilizing area, through which the vehicle and module must pass before entering the "clean" holding or parking area. The cleaning process is automatically controlled by the entrance of the vehicle. The batteries of the carts are recharged while they are in the holding area.

The cost of the Amscar system is high, but perhaps not excessively so when its many advantages are taken into consideration. Its total and best uses have not yet been fully tested in day-to-day operations in hospitals, but soon will be. Proposed installation of this handling system in existing structures presents some formidable obstacles. Installation costs may be expected to be considerably higher than in those planned installations in new buildings. However, the more desirable features of the system, which follow, would weigh heavily in favor of such an installation if a total handling system is to be considered.

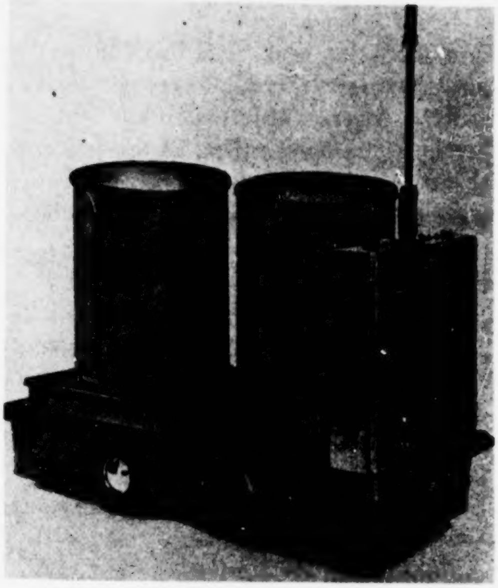
In no way is it suggested that Amscar or Mini-Cart systems be considered for the primary purpose of handling solid wastes. Such highly sophisticated conveying systems must first be considered as automated methods for delivering "clean" materials or supplies and removing "soiled" reusable items such as linens, dietary trays, and utensils which require reprocessing. Manpower saved by the abilities of these systems to respond to calls and obey electronic commands while almost totally unattended represents tremendous savings in dollars and


STEERING SERVO
TRACTION MOTOR
GUIDANCE CONTROL
STEERABLE WHEEL
SENSING COILS
ENERGIZED GUIDEWIRE

a. Amscar Vehicle Guidance System



b. General Purpose Module Mounted on Amscar Unit



c. Palletized Loading Technique May Also Be Used

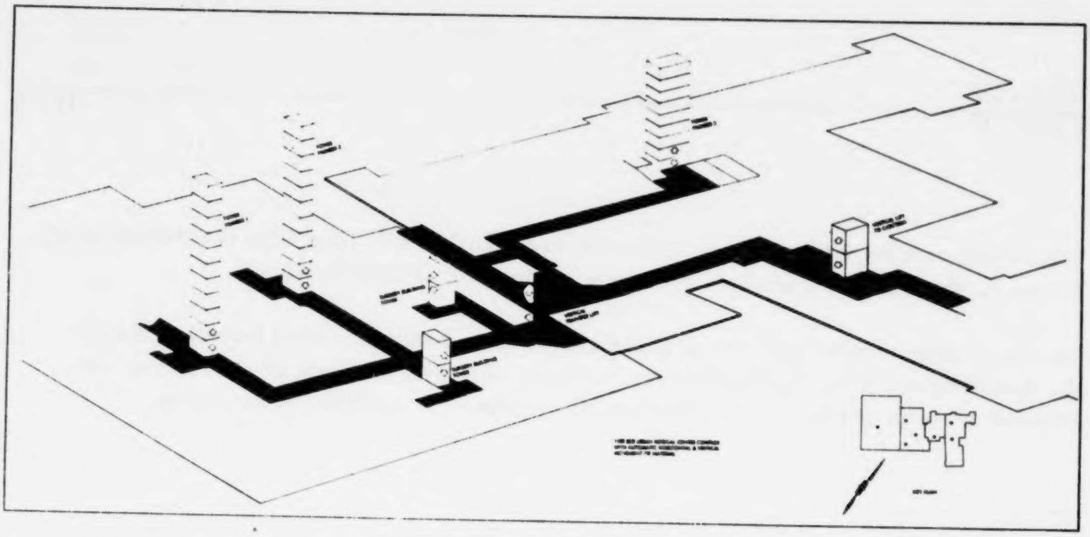
FIGURE II-3

assures obedient and prompt attendance to many institutional demands. The foregoing is not intended to eliminate consideration of this type of transport system for handling disposable solid wastes, but rather to emphasize the possibilities of such auxiliary use. If these primary uses can be economically justified by the complete types of studies done by the manufacturers, then, and only then, should any thought be given to its adaptation to the handling of the bulk of disposable solid wastes produced by the institution. Of itself and as originally conceived, it would not likely be an economically efficient method of handling disposable solid wastes. However, if waste handling can be added to its primary purposes, then such use could well prove to be a dividend which would further justify an expensive installation.

Unattended operation of this transport system in halls or passageways used by patients or visitors is not recommended. Although the carts are equipped with sensing devices which will halt motion on contact with any object, their unattended progress can be startling to the unsuspecting. The possible need for separate horizontal passageways for cart travel must be considered. Additional space is required for vertical lift shafts but it is probable that the same or more space would have been needed for larger elevators if conventional methods of handling were in use.

It is obvious that installations of this type of equipment are more practical when planned into new structures than when considered for additions to existing buildings. This does not preclude use in such existing institutions, however. Guidepath wires can easily be installed in saw-cuts in concrete floors or secured to floors under carpets. Horizontal travel on basement or supply floors and some vertical movement and limited movement on patient floors can be considered, but all are dependent on studies of conflicting traffic conditions. Such installations might be feasible where major expansion and remodelling of the facilities of a complex are under consideration.

Each installation presents its own set of complex problems and, unless all of the facts are known, estimates of the costs of installation cannot be accurately projected. The sizes (cubage and weight) and numbers of incoming and outgoing loads must be accurately known, kinds of materials, fixed delivery schedules, and many other factors must be studied before equipment requirements and cost



A Schematic Diagram of an Amscar System

Shown above is a schematic diagram of typical service level corridors and vertical shaftways required for the Amscar system. Straight horizontal passageways must have a minimum clear width of 7'-4" to permit two vehicles to pass abreast. Height of passageways should be about 7 feet, minimum. Vertical shaftways require minimum inside clearances of 5'-4" x 8'-6" for a single vehicle lift, or 11' x 8'-6" to allow adequate space for a lift to accommodate two vehicles.

Dimensions of the Amscar vehicles are 62"L x 26"W x 73"H, with the operating lever, or tiller, in the vertical position. The vehicle is capable of maintaining forward speeds of one to three miles per hour. Reverse speed is limited to one mile per hour. The gross carrying capacity of the vehicle is 900 pounds.

The dimensions of module or standard container is 53"L x 28"W x 59"H, or two inches wider than the vehicle, to allow for a bumper. Two styles of modules are available. They are identified as either general purpose or dietary, and will range in weight from 100 to 400 pounds, the latter being the dietary type.

prediction can be made. Labor rates and availability will likely be the determining factor in the economic feasibility of any contemplated installation.

No final determination on the possible use of such a sophisticated transport system for handling solid wastes should even be made until the methods of processing and disposal of such wastes have been studied by properly qualified technicians.

Chute, Gravity:

Next to hand-pushed carts, the gravity chute is the most common waste transport equipment to be found in hospitals and similar institutions. These installations usually consist of vertical cylindrical tubes, 12" to 36" in diameter, fabricated of stainless steel, aluminized steel or aluminum. Some tubes are made with a square configuration. The chutes are built into the building and are equipped with receiving doors on each floor. The chute is vented at the top and, in the case of chutes used for trash, the rooftop terminus is equipped with an explosion vent. Other applications of gravity chutes include spiral chutes for handling packages and containers. These are built around a central, vertical core and, while usually open, are available as closed types.

The doors of the receiving stations to linen and trash chutes can be supplied with either foot pedal, hand-operated opening devices or keyed locking devices. Interlocking systems are also available which automatically lock all doors except the one being open or, during cleaning operations, all doors on all floors. Complaints are numerous from maintenance engineers and housekeepers concerning malfunctions of doors and their control and locking mechanisms. Minor injuries have been sustained by personnel during operation of receiving doors. Such criticisms are aimed at nearly all manufacturers of chute installations.

The gravity chute is limited in its application, providing vertical free-fall, but some downward slope can be accommodated. It should not be considered a handling system, but a component. Properly installed and maintained, it is one of the most economical components of the total waste system. It is also adaptable to use in conjunction with horizontal mechanical conveying equipment for the continuing movement of linens or rubbish to central storage or processing points.

Collector, Litter, Vacuum:

This unique vacuum device, originally designed for collecting leaves and cleaning small, dry debris from shallow ditches, also has other applications and capabilities, such as cleaning general litter from around trash dumping or processing areas.

("Tecorp" - Truck Equipment Corporation)

This accessory, called a Tecorp Leaf Collector, can be added to a side-loader, mobile packer. It consists of a gasoline-motor-driven vacuum unit which can be mounted between the packer body and the truck cab. A large diameter, flexible hose and nozzle are connected to the unit when in use and can easily be handled by one man.

The manufacturer claims collected debris passes through a self-cleaning impeller fan which chops the material and blows it into the packer body. The suction hose is easily detachable for storing.

Conveyor, Belt:

Probably the most widely used of the many varieties of handling equipment, the belt conveyor is available in many forms and its applications are almost limitless. Basically, this general type of conveyor consists of an endless belt running between two rollers located at opposite ends of a supporting frame. A series of rollers or a flat metal bed support the belt throughout its length. The end rollers, one of which is powered, are usually tensioned to keep the belt reasonably taut and in contact with the driving roller. Lengths, loading, kinds of materials handled and other factors will govern the selection and arrangement of driving power.

The variations and arrangements of belt conveyors are almost endless. Such types as folding, extendible, portable, inclined, etc. are to be found in catalogs of many manufacturers. The belts are commonly made of canvas, cotton, nylon, rubber or woven materials impregnated with rubber or rubber covered. The use to which the equipment will be put will determine type selection.

Belt conveyors are used extensively in warehousing, manufacturing and processing industries, including applications in waste handling in bulk and containerized form.

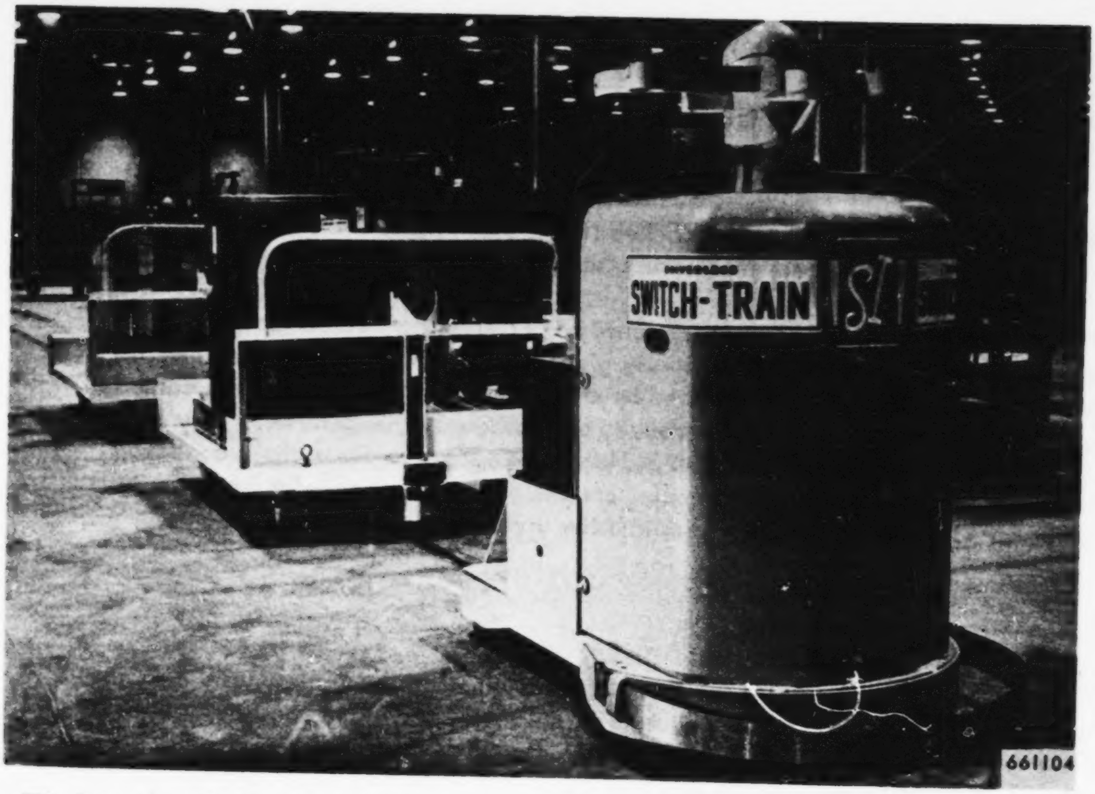
Conveyor, Chain, Drag:

This special type of conveyor used principally for the movement of dry, bulk materials is generally self-contained, self-cleaning and operates within its own casing. The transport mechanism is an endless chain to which "flyers" or paddles are attached at short intervals. As the flyers move through the enclosing square or rectangular shaped tube, the loose bulk material is dragged or pushed toward a discharge point or opening. Dry material, such as coarse sand and ashes, varying in granular sizes, can be handled. This type of conveyor is generally used for short, horizontal runs and has more limited capabilities than the tube conveyor discussed later in this chapter.

Conveyor, Chain, Drag, Driverless:

This battery-powered, driverless vehicle provides motive power to tow a train of unpowered carts over a programmed route. The driverless tractor drags a length of conveyor chain of the same style used by SI Handling Systems (described in detail in the next item). The tractor and chain follow a shallow slot in the floor. A guide pin on the centerline of each cart is inserted in the chain. The chain has "pusher dogs" spaced at intervals to accommodate the carts to be towed. The pusher dogs are special sections of the chain which have a raised formation just behind a recess. Each cart is equipped with a towpin which can be dropped into the chain slot in the floor. As the chain, being dragged by the tractor, approaches the cart waiting to be picked up, the towpin drops into the recessed section ahead of the pusher dog which, in turn, pushes against the towpin, thus moving the castered cart forward following the tractor.

Carts are added to the train by being hand-guided over the floor slot and the towpin engaged. Each cart is equipped with a pair of selector pins mounted on the front which can be preset to activate switches that will divert the cart off the main slot or track onto a spur track. This action is accomplished automatically and is controlled by the various combinations of selector pin settings. As the selector pins (which can be either electrical or mechanical) pass over the reader boxes or mechanical triggers (set in the floor), the pre-selected diverter is actuated and the towpin is diverted from the drag chain by a sideways sliding motion onto the spur track. As soon as the towpin has passed


SWITCH-TRAIN
SI
661104

SI's Driverless Switch-Train in Operation, Towing a Pair of Non-powered Carts the diverter, this mechanism is recocked in a closed position so that the following cart, unless programmed for that particular spur, cannot enter it.

The tractor can be programmed to proceed to and stop at selected locations. An audible alerting signal is automatically given by the tractor so that carts may be loaded, unloaded, removed or added by manual operation. The castered carts used are of simple design, easily moved, and relatively inexpensive. They are interchangeable with those used on SI Handling Systems in-floor chain conveyors. The pictorial description of this equipment included herein includes further details of the operation of the selector pins and the diverters.

Conveyor, Chain, In-floor:

This conveyor may be briefly described as an endless chain, continuously moving in a recessed and flush mounted housing in the floor, serving as the drive mechanism for a special cart system. Numerous manufacturers of this type of equipment are identified in the Product List (Appendix "B").

("Low-Tow" - SI Handling Systems, Inc.)

The equipment described herein is identified by the trade name "Low-Tow", as manufactured by SI Handling Systems, Inc. It has been selected for description primarily because it has been inspected in operation at two commercial installations (a large motor freight terminal, and a major chain store warehousing center). The freight terminal conveying system operates 24 hours per day, six days per week, and daily handles about one million pounds of freight. The total installed cost was about $400,000. This installation includes 3800' of powered mainline chain, 93 non-powered spurs, 2 powered spurs, and 1100 automatic dispatch switch-carts.

The merchandising service center system cost nearly $80,000. Of that amount, the 100 carts cost about $17,000. This system includes 1900' of powered drive chain, 35 spurs, totaling 900' of length, 2 powered drivers, and 100 automatic dispatch switch-carts.

The track, a shallow, "U" shaped steel channel with a narrow opening at the top, is embedded in the floor with the open top of the channel flush with the floor. This channel is the housing for the constantly moving endless chain which is the conveyor mechanism. The track and chain are kept properly lubricated. The endless chain passes over the drive sprockets and idler wheels of a drive unit, which is electrically powered. This drive unit is usually located in a pit in the floor. The pit has removable steel covers to allow access to the unit.

More than one loop of conveyor chain can be installed and it is possible to transfer carts automatically from one loop to another by means of a transfer conveyor. It is operated by a separate drive. Transfer is electronically controlled through special sensors and no operating problems are presented.

Details of the chain configuration, the pusher dogs and their functions, as described in the preceding section on the driverless chain drag conveyor, are the same type of components used in the in-floor chain conveyor and will not be discussed further. The diverters for both systems are the same. They are switching devices with their operating mechanisms enclosed in a box which is embedded in the floor. The movable diverter plate is flat and flush with the floor and channel. The diverter is connected to two trigger mechanisms. These may be either electrically or mechanically actuated. In either system, when the selector pins of any cart are set to coincide with a given spur diverter, the triggering device of that particular diverter, and no other, will function. The accompanying picture shows the diverter in a closed position. This prevents the towpin on the cart from entering the spur. The picture also shows the two selector pins, set for spur H-3, just approaching the reading coil box. As the selector pins pass over the coil box, a signal is transmitted to the diverter which will spring to the open position, as shown by the white dotted lines.

As the towpin reaches the diverter, the cart is shunted off the mainline chain conveyor and enters the spur under its own momentum. As the towpin passes the diverter, it recocks into the closed position, thus preventing unprogrammed carts from entering the spur. There is no power on this spur. The entering cart will be nudged further onto the spur by the following cart and there will be no interference on the mainline conveyor. If a second cart is programmed for this same spur, it enters in a similar manner and pushes the first cart further into the spur track. The mechanically operated diverter trigger functions in a similar way except that it will be intercepted by small spherical latches which protrude slightly above the floor.

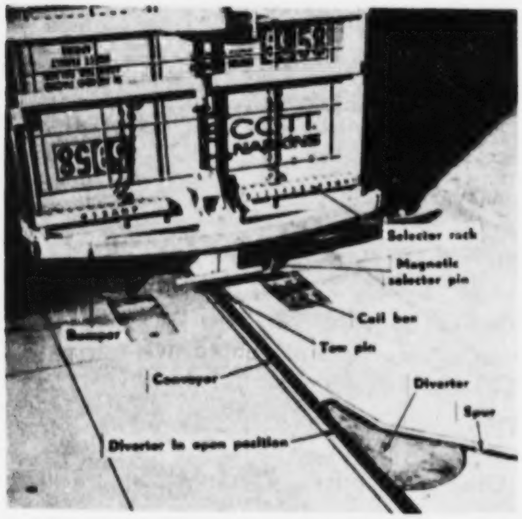
The selector pin arrangement has a capacity for 169 separate stations or spurs, if two pins are used. The destination selection is governed by the spacing of the selector pins from the centerline of the cart and track. When the settings of the pins and the locations of the diverter trigger coincide, the diverter will open but otherwise remain closed permitting travel of carts on the mainline chain only.

Chain speeds can be varied from 2 to 300 feet per minute. Some freight dock installations operate at 150' per minute. Normal warehouse operation will be between 60 and 80 feet per minute.

The towpins of the carts are held in a suspended position well above the floor when not in use on the chain. This permits free movement by hand to and from the chain and to desired points of use. When the cart is to be injected into the conveying system, it is moved over the chain, the towpin is released and dropped into the floor slot. This operation takes place between moving carts where spacing indicates an empty pusher dog. The top of the chain is smooth and until contact by a pusher dog link, the towpin rides along the lubricated flat top of the chain. Upon contact by the pusher dog, the towpin drops into the recessed front section of the dog and the raised pusher section imparts the chain's forward motion to the cart. The pusher dogs can be spaced from about eight to fifteen or more feet apart. This spacing is determined by loading requirements and is an engineering function to be considered in the design of the system.

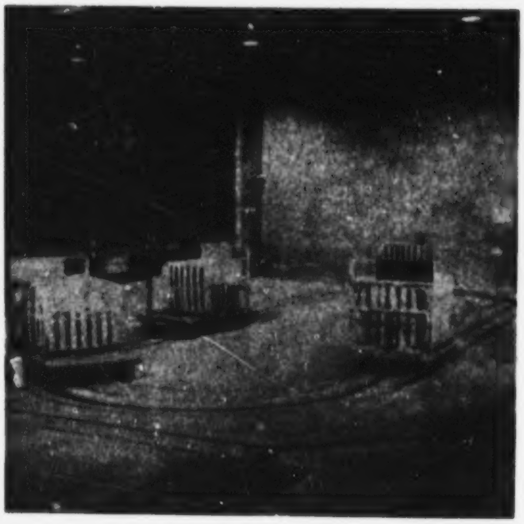
It is possible to provide ramped sections of this conveyor system so that carts may be operated on more than one level.

Some installations have been seen where several fire doors crossed the conveyor line. Closure of these doors is controlled by pressure-sensitive switches on the sprinkler system. If and when the sprinklers should operate, the fire doors would close off zones of the building. When this occurs, special diverters are electrically actuated, causing carts approaching the closed fire doors to be diverted onto special accumulation spurs. This prevents collision with the fire doors, which are closed across the towline track. Provision is also made for automatically shutting down drive mechanisms of the mainline and all other powered chains in the system.

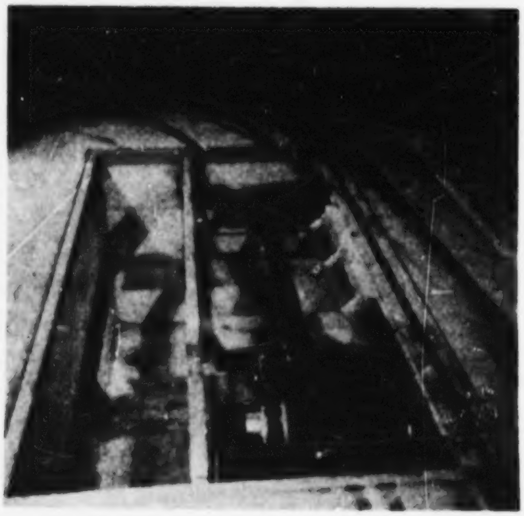

Selector rack
Magnetic selector pin
Coil box
Tow pin
Bumper
Conveyor
Diverter
Spur
Diverter in open position

a. Switching Controls of a Typical Lo-Tow Cart

b. Lo-Tow Mainline in St. Louis Freight Terminal



c. Test Track at Easton, Penn. Plant of SI Handling Systems, Inc.



d. View of Chain Drive Mechanism

LO-TOW - SI HANDLING SYSTEMS, INC.

FIGURE II-6

Carts for these systems are made to order and hence there is no standard size. A reasonable average cart platform would be about 36" x 60", varying in height from 8" to 12" above the floor. Heights of loaded carts, of course, will vary greatly, depending upon types of loads to be transported. It is estimated that gross weights of loaded carts may run between 600 and 750 pounds. Of these weights, carts will account for about 25 per cent.

The principal use of this type of equipment has been in industry. The in-floor conveyor systems, Switch-Trains and similar equipment are run in the open, where employees are used to the movement. If tunnels or passageways are found necessary, then horizontal clearances of one foot on each side of the widest cart should be provided. For systems having a single chain and 3' wide carts, it is recommended that tunnels be at least 5' wide. If two chains are used, the width should be increased to 9' to allow carts to pass each other. Tunnels should have minimum vertical heights of six feet. The foregoing figures apply to the Lo-Tow conveyor. If the Switch-Train, tractor type equipment is used, then widths of single tunnels should be increased to 6 feet, double tunnels to 11 feet. Heights will remain the same. Shaft dimensions should be 7' x 9' for single lifts, and 15' x 9' for double lifts. The elevators are capable of handling 5,000 pound loads, as regular equipment. A general rule-of-thumb would require one foot of clearance from any fixed object.

This type of conveyor can readily be used in non-pedestrian areas, in tunnels and separate passageways, and even out-of-doors between buildings. Small or large loops can be employed with few or many carts. The in-floor chain conveyor is not suggested as a total handling system but it can be adapted to certain uses within an integrated system.

It is not possible to provide accurate cost estimates unless all factors of loadings, timing, distances, etc. are known. Cost indicators on trackage of a simple installation have been calculated at about $20.00 to $25.00 per lineal foot. To this must be added from $150.00 to $400.00 per cart, depending upon design.

Conveyor, Chain, Overhead:

Industrial usage of the overhead chain conveyor is widespread and still growing, but the principles involved have many other applications. The overhead chain conveyor of today is frequently an automated system with sophisticated electronic controls. The chains may be semi-enclosed in tubes and of many different styles and types. Carriers having rollers or wheels which ride on various types of overhead track are integral parts of the chain assembly. The generally accepted concept of this type of conveyor is not particularly suited to the uses with which this report is concerned. There are, however, some variations of the application of chain conveyors that are, or might be, useable in multistory building complexes.

Various manufacturers produce and market systems with similar mechanical and operational characteristics. From these, we have selected the "Power-Flex" and "ACTE" systems, designed and installed by Columbus McKinnon Corporation, as being illustrative of what can be accomplished with an overhead chain conveyor as a general materials handling system.

("Power-Flex" - Columbus McKinnon Corporation)

One of the "Power-Flex" installations inspected has been in daily operation over a three year period in a major department store located in a southern California regional shopping center. This system was designed for material distribution and waste handling in this three story building containing nearly 200,000 square feet of gross area.

A central receiving and distribution center supplies this department store and another unit of the same chain. The distribution center and each of the retail outlets are equipped with "Power-Flex" systems. New merchandise is processed, containerized and loaded directly at the distribution center. These containers or system carts are manually rolled onto trucks for transport to the designated store. Upon arrival, they are manually pushed off the trucks and inserted into the store's conveyor system for automatic delivery to pre-selected destinations within the retail unit. When not required for in-house use, the empty carts can be returned to the distribution center for recirculation.

This installation inspected combines both powered and free rails in the horizontal transport components and vertical transport components are designed to serve the system exclusively. The horizontal conveyor network forms continuous loops or service corridors running around the perimeter of the building on each of the sales floors. These perimeter service areas, containing other service functions as well, are separated from the inner public areas. The horizontal conveyor system is serviced by vertical lifts located in each of the four corners of the building.

There are 100 carts of various styles in use in the system. The carts used are of simple design and are castered to allow easy manual movement in sales and service areas. Some are simple cages; others are closed containers with doors which can be locked. A specially designed trash cart incorporating an automatic self-dumping feature was developed for the system.

The system's motive power is supplied by a semi-enclosed power chain composed of a series of vertical and horizontal roller wheels which operate on the bottom and sides of the enclosing channel. Pusher pendants are attached to four-wheeled trolley carriers, spaced a few feet apart on the chain. These pusher pendants engage with the trolley carriers when the trolley is injected into the system.

The carts to be transported are manually pushed under any of the entry stations on the system. The cart is easily attached to a trolley carrier, the "Telematic" automatic dispatch control set for the cart's destination and the trolley, with cart attached, is released. When an unoccupied pusher pendant approaches the entry spur, the loaded trolley is automatically released into the main line, by gravity, and is then engaged by the pusher pendant and moves with the main drive chain.

When the trolley carrier, with its attached cart, arrives at the destination spur or turnout, it is automatically shunted off the main line. The trolley and cart are stopped by a retarding mechanism. The carts are manually detached from the trolley and rolled to the desired location.

Carts destined for other floors are automatically injected into a vertical lift and automatically ejected at the selected floor. The injection and ejection operations are accomplished by gravity on power free rails.

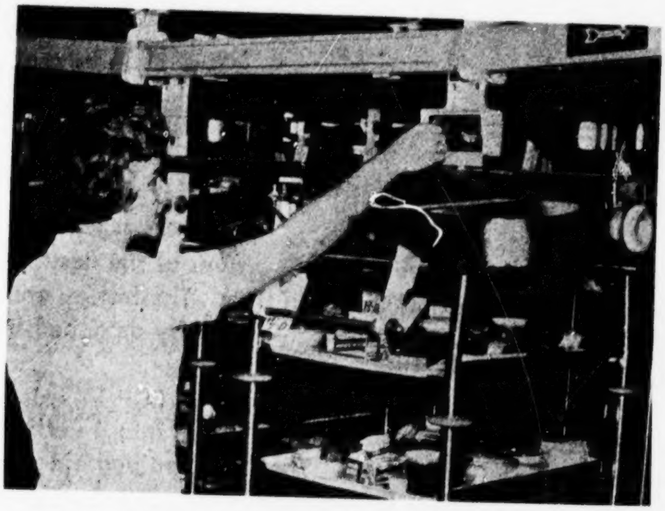
The method of handling waste paper and rubbish is semi-automatic. Six specially designed trash containers are used exclusively for the transportation of wastes throughout the system. These containers are equipped with permanently attached trolleys and "Telomatic" control heads. The control head is permanently set for the container to orbit the trash route, discharge contents and return to assigned station. These special containers have an automatic bottom-dump mechanism which opens the bottom doors as the container passes over a trash chute on an upper floor. After the trash has been dumped, and the cart passes beyond the trash chute, the doors are automatically returned to the closed position. The trash chute empties into bulk storage rubbish containers on the ground floor. A private waste hauling contractor periodically empties the containers into his mobile packer and hauls the wastes to an off-site disposal point.

The installed cost of this conveyor system, including 100 carts and approximately 3,500 lineal feet of track, was about a quarter of a million dollars.

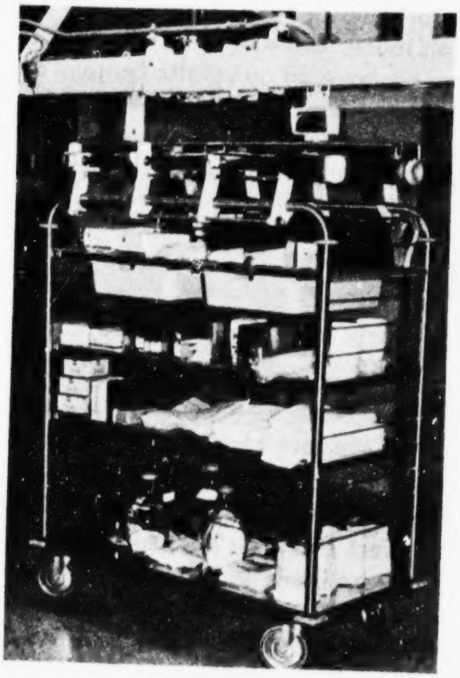
("ACTE" - Columbus McKinnon Corporation)

Another overhead chain conveying system manufactured by Columbus McKinnon is known as ACTE - Automatic Cart Transport Equipment. It was designed especially for handling supplies, dietary items and linens in hospitals. ACTE installations are reported planned for or already under construction at Laguna Hills Hospital, California; Mercy Hospital, Buffalo, New York; Wadley Hospital, Texarkana, Texas; Providence Hospital, Cincinnati, Ohio; and elsewhere.

Similar to the Power-Flex system, ACTE handles typical hospital carts which

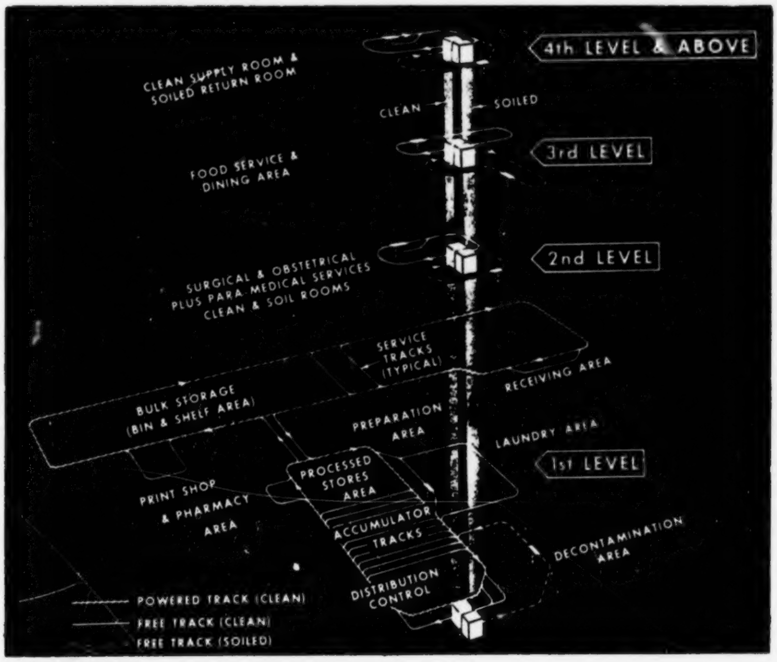


a. Technician is "dialing" destination code on the "Telematic" control, programming either a point-to-point or sequential routing.



b. Standard supply cart traveling six inches off the floor to its previously dialed destination.

FIGURE II-7


4th LEVEL & ABOVE
CLEAN SUPPLY ROOM &
SOILED RETURN ROOM
CLEAN
SOILED
3rd LEVEL
FOOD SERVICE &
DINING AREA
2nd LEVEL
SURGICAL & OBSTETRICAL
PLUS PARA-MEDICAL SERVICES
CLEAN & SOIL ROOMS
SERVICE
TRACKS
(TYPICAL)
BULK STORAGE
(BIN & SHELF AREA)
RECEIVING AREA
PREPARATION
AREA
LAUNDRY AREA
1st LEVEL
PRINT SHOP
& PHARMACY
AREA
PROCESSED
STORES
AREA
ACCUMULATOR
TRACKS
DECONTAMINATION
AREA
DISTRIBUTION
CONTROL
POWERED TRACK (CLEAN)
FREE TRACK (CLEAN)
FREE TRACK (SOILED)

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ACTE (Automatic Cart Transport System)

Shown above is a schematic diagram of a typical ACTE installation. ACTE uses standard hospital carts with typical dimensions of 48" long by 54" high by 27" wide, down to and including tote box dimensions, all of which may be carried on the same system. The weight of carts or modules depending on size, design and materials, range between 25 and 200 pounds. Load capacity will range between 300 to 500 pounds for the larger dimension sizes. Common or average speeds of operation for the horizontal travel of this conveyor is 40' per minute. Vertical transportation is accomplished at elevator speeds (to 500' per minute).

This equipment requires average clearances of two feet on each side of the track's center line. Vertical clearance for ACTE, where cart will be carried just above the floor, range up to 8' minimum on larger carts. 15' clearance, floor to ceiling, will allow transportation of larger carts overhead, above false ceilings.

Horizontal tunnels should be 8' wide and 8' high to accommodate passing carts and low density foot traffic.

Vertical shafts for reciprocating single-cart styled vertical conveyors require a space of 7'6" by 9'2" for high rise lifts and 6'10" by 8'6" minimum for low rise shafts.

FIGURE II-8

ACTE - COLUMBUS McKINNON CORPORATION

can easily be attached to or detached from special trolley carrier bars. "Telematic" control heads are mounted on the carrier for programming the route of both the carrier and cart.

Carts are introduced into or removed from the system by either of two methods. One employs a section of non-powered track which can be raised or lowered by electro-mechanical means to pick up or deposit a cart. The other method involves a section of gravity track which is depressed sufficiently below the level of the operating track to allow the wheels of the cart to touch the floor. When the cart is solidly on the floor, it can be easily released from the trolley by means of a manually operated unlocking bar.

In hospital installations of ACTE, two separate vertical lifts can be provided for separated movement of clean supplies and soiled items. All returned carts are cycled through a decontamination area before reuse.

Cost figures are not presently available for this type of system. However, for a typical 500 bed hospital, the manufacturer estimates that through semi-automation, a direct "payout" of five years could be anticipated from reduced operating costs in comparison to operating costs of the conventional cart system that is normally used.

Conveyor, Monorail, Electric:

The concept of an electric monorail conveyor, as defined, is limited for purposes of this report to continuous structural power rails carrying heavy-duty self-propelled transporters on horizontal, vertical and inclined routes. Although several manufacturers produce such classified systems for industry, the only system found specifically designed for general materials handling in hospitals was the "Cyberail" system.

("Cyberail" - Castle Automated Systems)

The "Cyberail" monorail conveyor, produced and marketed by Castle Automated Systems, is a highly sophisticated transport system consisting of a network of suspended horizontal and vertical trackage for movement of materials and supplies between various stations within the system. Two vital elements of the Cyberail system are the special motorized transporters and modular containers. These components, carried on the monorail track, usually operate within their own shafts and tunnels, except for injection and ejection at the various stations in the system.

The transporter is self-propelled and driven by two 2hp, 208 volt, three phase motors. Two small motors are used in order to provide adequate motive power within limited space. Power is supplied to the motors through buses, which are an integral part of the track. The function of the transporter is to pick up, transport and deposit containers on a demand basis at the various stations within the system. A leveling device retains the containers, or modules, in an upright position at all times, regardless of the angle of inclination of the track or any off-center loading of the container.

Typical containers or modules are constructed of stainless steel and have tightly sealing doors and removable shelves. The containers can be made to special designs but are limited to standard overall dimensions in order that they fit the transporter. Containers weigh up to 170 pounds and have a payload capacity of about 220 pounds and volume capacity of approximately 16 cubic feet.

The operation of the Cyberail system is completely automated with the exception of the actual loading and unloading of the modules. The system can contain a large number of stations, each of which is equipped with a control panel for summoning or dispatching transporters. Sterilized containers can be summoned from the container wash and storage area. An empty transporter can be summoned for the purpose of removing a module awaiting pickup from a particular station. Transporters, with or without modules, can be dispatched from any station to any other station in the system.

A module is shown, in the accompanying photograph, emerging from a vertical shaft of the system. The control panel is shown at the right. This container has been dispatched from the supply area to this particular station. The transporter has carried the container horizontally, through the service tunnel on a lower floor, and upward in the vertical shaft. When the transporter reaches the programmed destination, the sliding doors to the shaftway at the receiving station are automatically opened. The module is then ejected by the transporter and the doors automatically close immediately behind the module. The module is automatically moved along one of the walls, in order to free the shaft access doors and provide space for both additional modules to be received, as well as room for dispatching others. The modules are equipped with large casters and can be easily rolled by hand from or to the control station.

An accompanying photograph shows a module held by the transporter, which is on a portion of the horizontal trackage of the system. It should be noted that the vertical track differs from the horizontal track in that a rack gear is mounted on the base of the track to give positive drive in vertical movement.

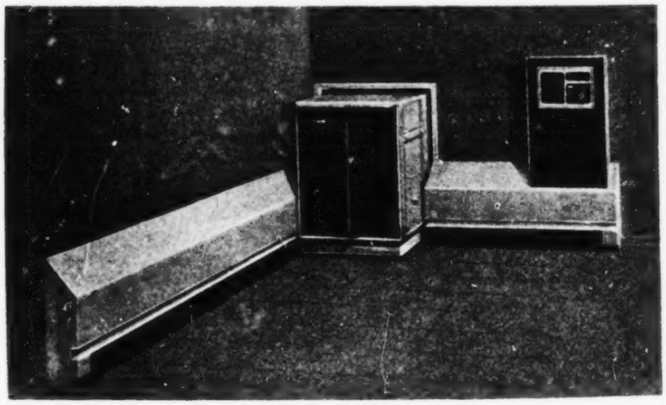
The Cyberail system operates on the loop principle and hence can provide a clean side and a soiled side for transport. Although originally visualized as a system for handling clean materials from supply areas to nursing stations and removing soiled reusable items from those stations, its adaptation for handling disposable wastes is also possible. The initial cost of this system is high and therefore should not be thought of as primarily for waste handling.

The system is designed with a container wash and storage area to keep a supply of sanitized containers available to all users. When a container is no longer needed by a user, it is sent to this area, inspected to ensure that no material has been left aboard, and then automatically processed through a washer/dryer prior to storage in a clean holding area. Transporters can be dispatched from the various stations to pick up a sterilized container.

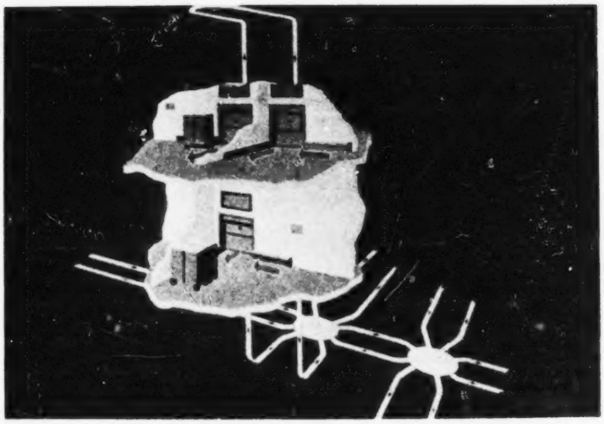
It is not possible to estimate the cost of a system accurately unless complete plans are available and an extensive study made. However, the manufacturers estimated net costs of an installation for a 400 bed hospital at about $1,600,000, considering savings of items replaced by the Cyberail system, such as conventional cart systems, building space etc. It was estimated that the "payback" would require about nine years.

Other cost indicators were provided, based on the probable requirements of a hypothetical 1,000 bed hospital. Preliminary estimates indicated that 42 transporters at $15,000 each and 300 containers at an approximate cost of $800 each would be required, or about $870,000 for accessory equipment alone, excluding the cost of track, shaftways and tunnels, control stations, etc.

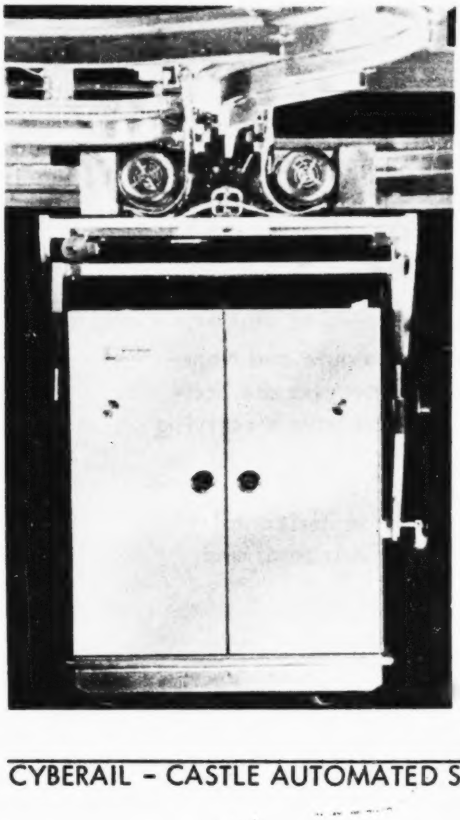
An outstanding feature of Castle Automated Systems' approach in determining requirements of a proposed installation is the detailed study which must be under-



a. Typical System Station

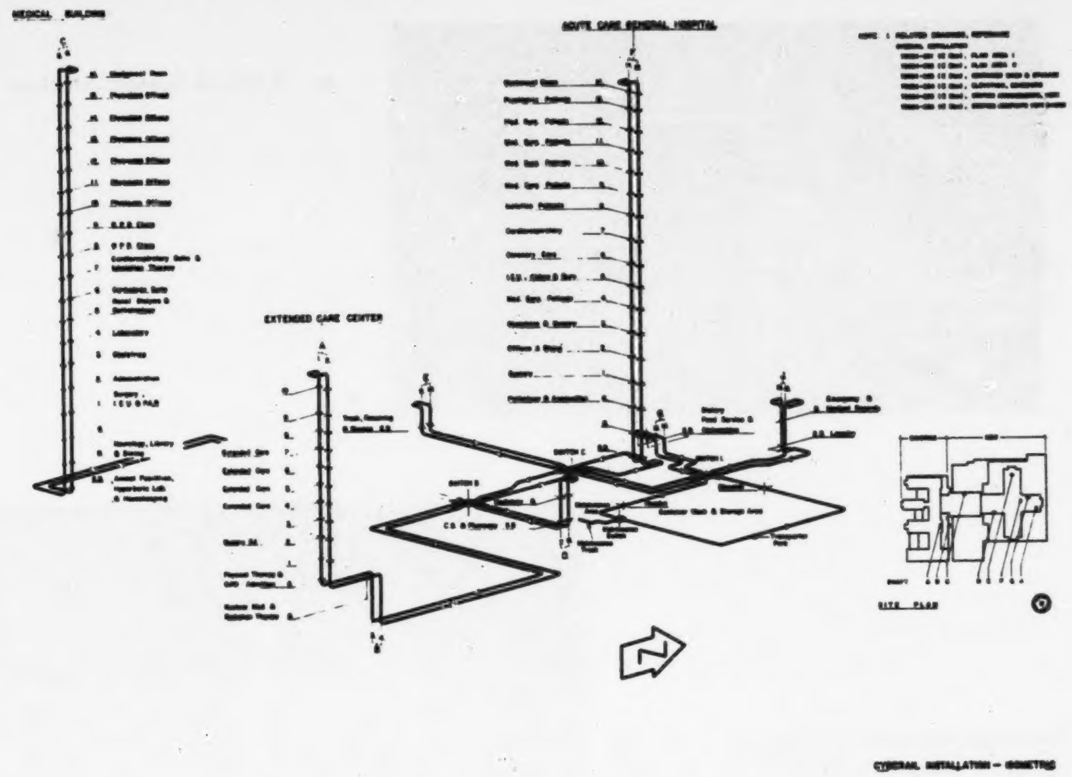


b. Schematic of Typical Cyberail Installation



c. Container Module Suspended from Transporter

FIGURE II-9


MEDICAL BUILDING
ACUTE CARE GENERAL HOSPITAL
EXTENDED CARE CENTER
SITE PLAN
CYBERAIL INSTALLATION - ISOMETRIC

A Schematic Diagram of a Cyberail System

Shown above is a schematic diagram of a typical service tunnel system with vertical shaftways for routing Cyberail trackage and modules. Tunnels large enough for two transporters to pass each other should be 10' wide and 7'-6" high. Vertical shafts require a space 5' x 5' for each track or about 11' x 5' for a dual operation.

Standard modules are 40" L x 25" W x 49" H. The module and transporter combined will be 5'-0" W x 6'-6" H. These modules are constructed of stainless steel, weigh up to 170 pounds and have a carrying capacity of about 16 cubic feet or 220 pounds.

Loaded transporters travel about 200 feet per minute on horizontal track and 100 fpm in the vertical shafts. Speeds on horizontal and vertical curves are somewhat lower.

FIGURE II-10

taken before any recommendations can be made. The total operation of the existing or planned hospital is studied in depth, such as the number of daily moves, types and sizes of loads, distances to be traveled and many other factors being used in the computations. These figures are used in a computer simulation to determine the feasibility of the contemplated Cyberail installation. It is by this means that the potential customer can be properly guided in his judgment before contracting for such a system. Castle Automated Systems will undertake such a study for a predetermined fee, which will be credited to the client against the total cost of the installation if the system is acquired.

Installations of Cyberail are planned for or being installed in several hospitals. These include the University of Connecticut Hospital at Farmington, Connecticut, the Hospital of the Good Samaritan, Los Angeles, California, three Veterans Administration Hospitals located in Atlanta, Georgia, Washington, D.C. and Woods, Wisconsin.

Conveyor, Pneumatic:

This conveying method, employing tubes in which air, under either positive or negative pressure, is used to move carriers, objects or bulk materials. The form in which this type of conveyor is best known is the pneumatic tube system used to transport documents and small objects within buildings and institutions, such as hospitals. This small pneumatic tube system is still effectively used in hospitals but its size and limited capacity removes it from consideration in this study.

Application of pneumatic conveying for movement of loose or bulk materials is common in industry today. These, as well as specialized systems, have considerable merit for the handling of wastes. Several systems developed for the movement of waste materials have been investigated during the course of this study. Each, having certain variations in their application, are discussed separately herein.

("AVAC" - Aerojet General Corporation)

A pneumatic transport system, originally developed in Sweden under the trade name "AB Centralsug", is now produced and marketed by Aerojet-General Corporation under the trade name "AVAC" - Automated Vacuum Collection Systems. An operating pilot plant, shown in the accompanying photograph, was built at the Aerojet-General plant at El Monte, California, for demonstration purposes.

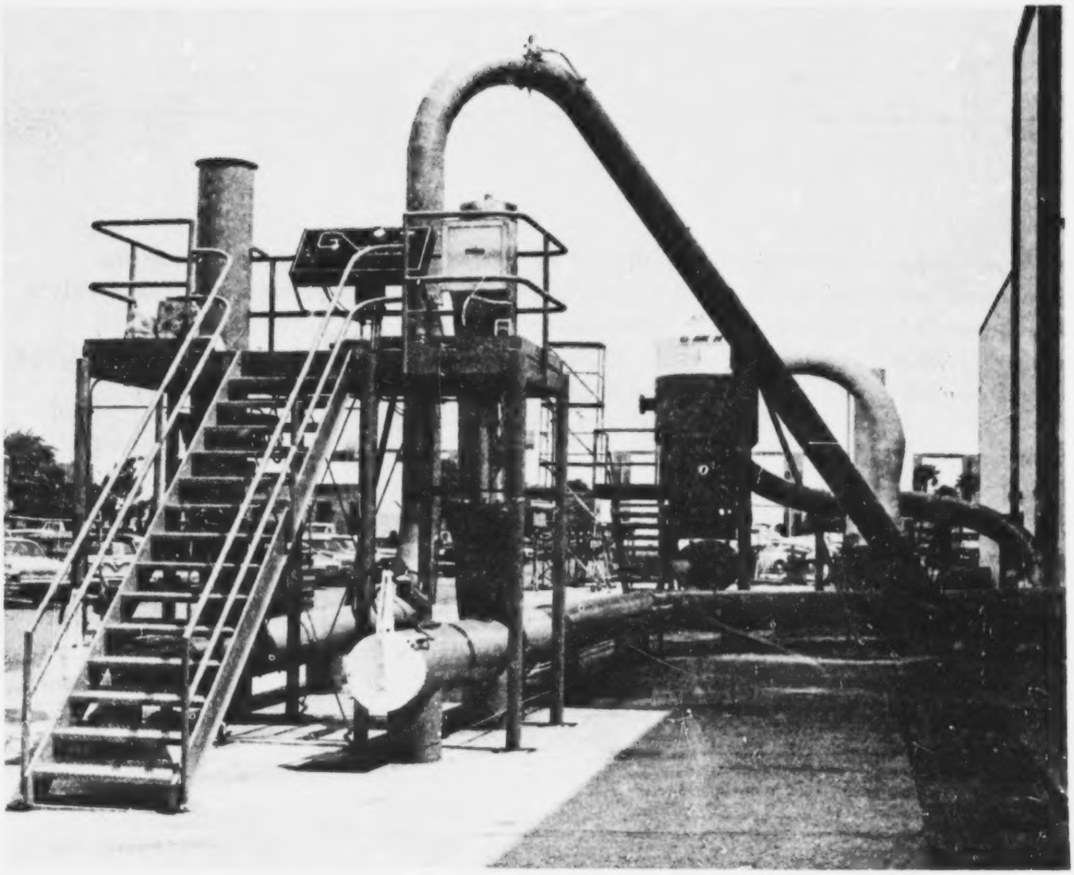
The AVAC system is described by the manufacturer as a horizontal system of pipes with an exhauster at one end and air inlets at the end of each branch line. When the system is in operation, a vacuum is developed at the inlet of the exhauster and a high velocity air stream is drawn through the transport pipes from the air inlets, one at a time. Throughout the system, vertical gravity chutes are provided and connected to the horizontal pipe system. Material, for example trash or soiled linen, is collected in the vertical chutes and then dropped into the moving air stream, one chute at a time. The air stream carries the material to a collection hopper, leaves the material in the hopper, continues on to the exhauster, and then discharges to the atmosphere. Air moves in the system at the rate of 80 feet per second or about 60 miles per hour.

Construction materials and sizing of the tube system can, of course, vary if special requirements of a particular project so dictate. However, a typical system utilizes the following materials:

20-inch diameter pipe of carbon steel, coated and wrapped when used underground;
A pipe wall thickness of 3/16-inch for all buried lines and for trash lines aboveground;
A pipe wall thickness of 1/8-inch for soiled linen lines, air exhaust pipes aboveground and material storage sections;
Aluminized steel vertical chutes of 14-gage; and
Epoxy-lined soiled linen transport pipes.

The manufacturer further states that the pipe now being used is spirally wound, carbon steel, weighing about forty pounds per foot. Insulation consisting of 1/64-inch lead sheeting and 1-inch thick fiber glass are used. Cathodic protection is recommended for pipe subject to corrosive soil conditions.

Actuation of the AVAC system is automatically controlled from a central panel. A timer may be employed to initiate operation. Upon initiation, the exhauster is started and simultaneously the inlet air valve nearest the exhauster opens. After



AVAC Pilot Plant - Aerojet-General Corporation

A general view of the demonstration installation of the Automated Vacuum Collection System (AVAC) at the El Monte, California plant of Aerojet-General Corporation. The receiving hopper and control panel are shown on the right side of the platform.

FIGURE II-11

air flow has been established, the discharge valves in the particular branch are sequenced individually. Sequencing of inlet air valves and vertical discharge valves on the remaining branches is performed automatically, each valve in the system operating for a fixed time interval. Automatic, non-scheduled operation of discharge valves can be incorporated into system controls to handle demand situations.

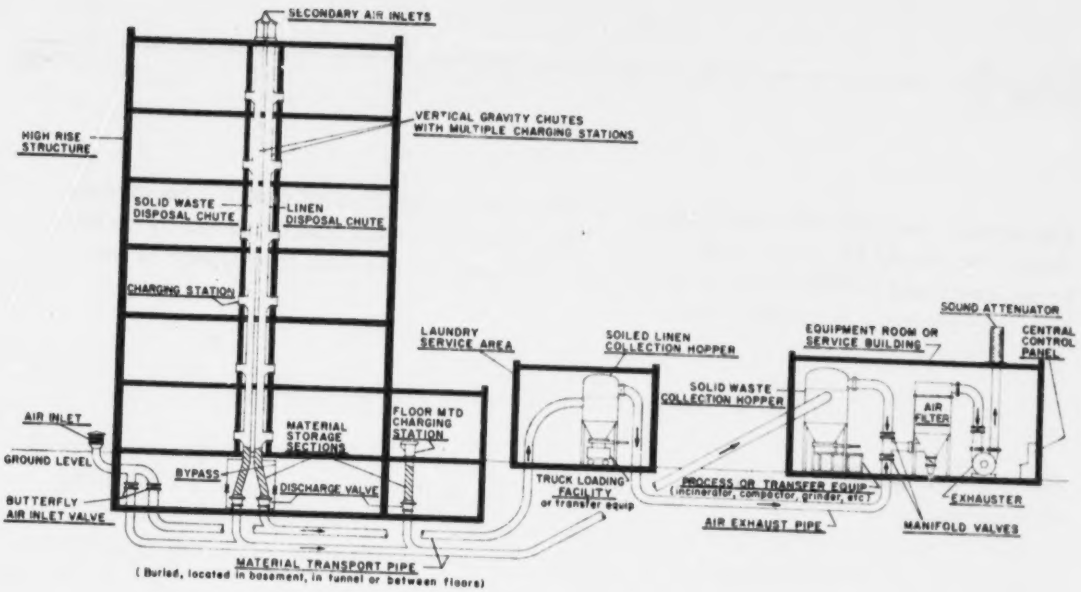
At the completion of the sequence, all valves are closed and the exhauster shuts down. Between cycles of the system, a collection hopper is automatically emptied, discharging into storage hoppers or specific items of equipment for ultimate disposal or processing.

Either single tube systems may be employed for separate cycling of soiled linens and disposable wastes, or dual tube systems may provide for complete separation in the movement of these materials. A schematic diagram as prepared by the manufacturer and included herein shows a typical dual tube system installation in a multistory building.

It should be noted that the AVAC system has capability to move material in any direction, under air power, after material is discharged from chute storage into the airstream. Initial vertical movement is limited to a downward direction from conventional gravity chutes. The manufacturer claims and demonstrates in the pilot plant that material can be lifted about 30 feet vertically.

The system is not continuous in its operation. It must be actuated either by push button or placed under a time-cycle control or on a demand basis through limit-switch controls at storage points. This intermittent operation has some operating cost advantage but also necessitates some attention by operating personnel. Since the operation of the system is not continuous, some storage space of materials awaiting horizontal transport is required. This storage space is provided solely by the lower extremities of the vertical gravity chutes. Although the AB Centralsug system is in operation in some hospitals in Sweden, the adequacy of this storage concept has not yet been proven by any operating installations in the United States. However, in theory, with adequate limit controls within the chute storage areas, this method appears to be feasible.

The manufacturer states that an AVAC installation is contemplated at Walt Disney World, the 27,000 acre entertainment resort now being built near Orlando, Florida.


SECONDARY AIR INLETS
VERTICAL GRAVITY CHUTES WITH MULTIPLE CHARGING STATIONS
HIGH RISE STRUCTURE
SOLID WASTE DISPOSAL CHUTE
LINEN DISPOSAL CHUTE
CHARGING STATION
SOUND ATTENUATOR
LAUNDRY SERVICE AREA
SOILED LINEN COLLECTION HOPPER
EQUIPMENT ROOM OR SERVICE BUILDING
CENTRAL CONTROL PANEL
SOLID WASTE COLLECTION HOPPER
AIR FILTER
AIR INLET
MATERIAL STORAGE SECTIONS
FLOOR MTD CHARGING STATION
GROUND LEVEL
BYPASS
DISCHARGE VALVE
TRUCK LOADING FACILITY or transfer equip
PROCESS OR TRANSFER EQUIP (incinerator, compactor, grinder, etc)
BUTTERFLY AIR INLET VALVE
EXHAUSTER
AIR EXHAUST PIPE
MANIFOLD VALVES
MATERIAL TRANSPORT PIPE
(Buried, located in basement, in tunnel or between floors)

Schematic Diagram of an AVAC System

Shown above is a simplified diagrammatic sketch of a typical dual system for transporting solid waste and soiled linen. Directly above in the sketch is the air inlet, a screened opening. In a system with branches, butterfly valves are provided downstream of the air inlet to ensure that only one branch operates at any given time.

Proceeding to the right of the air inlet, the sketch portrays two vertical gravity chutes - one for solid waste and the other for soiled linen - with charging stations on each floor of the structure. At the bottom of the chutes, material storage sections and pneumatic cylinder-operated slide-type discharge valves are incorporated.

In multistory buildings, bypasses normally will be provided around the valves to allow a constant air flow and to maintain a slight negative pressure in the vertical chutes. This is maintained by a small exhaust blower. As indicated, secondary inlets are provided at the top of the chutes on the exterior of the structure. This arrangement continually removes air carrying dust, odors, or contaminants from the vertical gravity chutes. When the system includes a series of vertical chutes in one branch, the discharge valves will operate in sequence; the first valve to open will be the one closest to the exhauster. To the right of the gravity chutes (the next branch downstream) is a typical floor-mounted charging station. Such units can be provided in the garden for cuttings, in the kitchen for cans, boxes, bags, wrappings and other waste; or in any area in which there might be a rapid accumulation of waste.

A high velocity air stream carries the materials from the material storage sections and discharge valves through the material transport pipes to their respective collection hoppers in the laundry service area, and in the equipment room or service building. The air continues through the collection hoppers leaving the material load in the hopper. A grating or screen is provided in the hopper to protect the exhauster by preventing coarse materials from being carried further downstream. Provisions are generally made for automatic removal of trash from the solid waste collection hopper to such processing equipment as shredders, balers, compactors, incinerators or other equipment used for trash disposal. From the soiled linen collection hopper, automatic removal is generally provided to a truck loading facility, or to transfer equipment for removal to appropriate stations in the laundry.

The air then flows through air exhaust pipes and manifold valves to an air-cleaning device (identified in the sketch as an air filter). The extent of filtration is determined by specific customer requirements. A wide range of filters is available, from throw-away types of nominal capability to bag filters, electrostatic filters, or absolute filters.

Finally, the air discharges through the exhauster, which is a heavy duty blower. The capacity of the exhauster is determined by the length of the runs, the materials to be carried, piping configuration, and other design parameters.

The sketch indicates a sound attenuator at the exhaust end of the line on the exterior of the equipment room or service building. Requirements for noise reduction devices will vary dependent upon the distance of the exhaust from occupied buildings and the nature of the occupancy. Noise reduction can be accomplished by enlarged exhaust outlet ducts, insulation, baffled chambers, or mufflers.

The system, as presently anticipated, would have 7,500 feet of pipe. The longest single run would be about 4,500 feet. The exhausters would be powered by 1-100 horsepower and 1-200 horsepower motors. The cost of the installed system is estimated to be more than $600,000.

("Air-Flyte" - Eastern Cyclone Industries, Inc.)

Eastern Cyclone Industries, Inc. designs, manufactures and installs negative pressure air conveying systems called "Air-Flyte". Originally designed for linen handling in laundries, especially those providing diaper service, it has been adapted for installation in a large number of hospitals. In some institutions, it is being used for both soiled linen and trash handling.

E.C.I. Air-Flyte uses negative air pressure to move linen or bagged wastes to points of processing or disposal through a tube or piping system from depository stations, strategically located within buildings or a building complex. The most common system employs a single tube, usually between 12 and 20 inches in diameter. Automatic switching devices make it possible to divert linens or trash to the proper destination. Single tube systems can be equipped with either one or two-door depository stations, although both in the latter case are connected to the same single tube. Systems can also be installed in which separate tubes are provided for linen and trash. The operations of single or two-door systems and single or dual tube systems are controlled by push button.

The operation of an Air-Flyte pneumatic conveying system at Alta Bates Community Hospital at Berkeley, California, was inspected in mid-1969. This hospital was established in 1905 and has recently undergone extensive expansion and now has a capacity of 245 beds. A description of the pneumatic conveyor recently installed in a five story addition to this plant follows.

The pneumatic conveyor installation consists of a single tube system, equipped with seven receiving stations. Each station is served by a single outer door and has two control buttons, one to actuate the relays and switches which control the routing of waste or trash, and the other to select the routing of soiled linen or trash to the proper destination in the basement. The receiving stations are located inside of small trash and utility rooms, where access is limited to authorized personnel. The manufacturer recommends a two-door system inasmuch as it provides a method for obviously channeling soiled linens and trash to the appropriate destinations. However, in this installation at Alta Bates, in an effort to economize, the hospital chose to install a single-door system.

Each receiving station consists of a built-in housing with an outer access door flush with the wall. An inner door, which is air-operated, provides the closure between the receiving station and the main air tube of the system. The outer door can be opened only when the inner door is closed and thus no air from the system is expelled into the building nor can inside air be drawn into the system.

All wastes and soiled linens are bagged on the patient floors in either paper or plastic bags, depending upon the types of materials. These bagged materials are put into the conveying system by hospital personnel as demands require. Bagging is considered essential to prevent heavy objects from falling out of the airstream. Since the system operates on negative pressure, the materials introduced into the tube are pulled through the system rather than pushed. Materials moving in the system are considered to be carried in suspension at approximately 80 feet per second or 60 miles per hour.

When a bag of trash is to be introduced into the system, the outer door is opened, the bag is placed inside the receiving station, the outer door is closed, and the trash button pushed. By means of an electronic memory and a series of actuating relays, the inner door is automatically opened and the bag is drawn into the air tube. The electronic controls will also actuate switching mechanisms within the Air-Flyte system which will direct trash and soiled linen to the proper destination when properly instructed.

From the foregoing description of the single door system, it is obvious that a "people factor" is involved in the operation of the system and that it will be a more critical factor in this system as opposed to one having separate doors for trash and linen. The use of a two-door system does not eliminate the possibility of incorrect dispatching, but it does make some initial thought and decision necessary to accomplish the operation. When a second door is used, it could be equipped with a foot lock, a second latch or a key on the trash door to help insure proper operation.

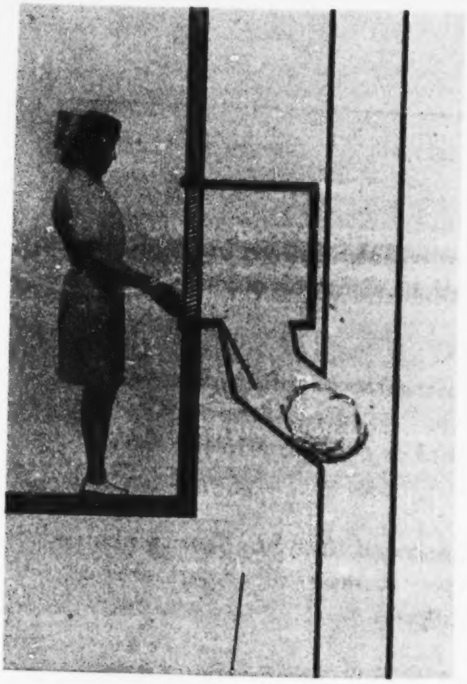
The system is engineered to dispatch but one bag from one receiving station to a selected destination at any given time. The memory system, like the type used for elevator control, will record demands from a number of stations and actuate the inner doors of the various receivers throughout the system in a time sequence corresponding to the order in which the demands were placed. When one delivery is completed, the next in the demand sequence will be commenced and subsequently completed before a following cycle will begin. In this particular installation, the longest run of air tube is 300 feet and the maximum cycle of operation for the movement of one bag requires only eight seconds.

Necessary fire control devices can be incorporated in the Air-Flyte system. Fire dampers, which are accordion-pleated devices that drop vertically across the airstream, are controlled by fusible links and can be installed in accordance with prevailing codes. Likewise, sprinkler systems can be installed to comply with local regulations.

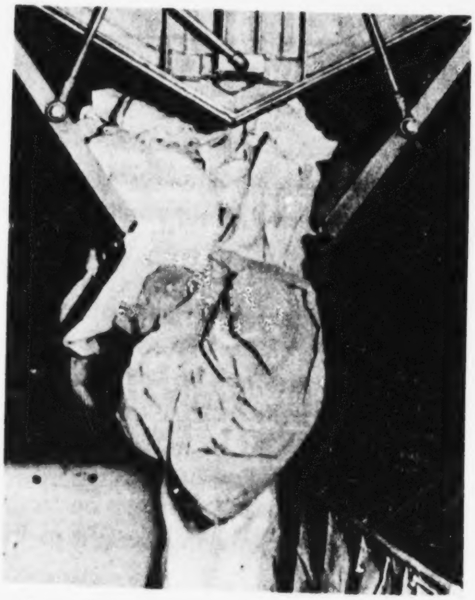
In the Alta Bates installation, an 18-inch air inlet, the exhaust stack, and fan (exhauster) room are located on the roof. The exhauster is in constant operation but a damper controls the system so that until a receiving station door is actuated, no air is moving in the conveyor tubes. When a receiving station button is pushed, the damper is actuated and permits air at about 9,500 cfm to enter the system. When the transport operation is completed, the air from the exhauster is bypassed to the atmosphere. The main conveyor tubes are 16 inches in diameter.

The plant of Eastern Cyclone Industries, Inc. was visited at Fairfield, New Jersey, where sheet metal fabricating work is done. The cylindrical tubes are usually fabricated in 8-foot lengths and are subsequently assembled on the job site. Bends are made to a square cross sectional configuration, thus providing a smooth, flat surface for the curved walls of a 45°, 90° or other bends. The tubes are insulated with one inch, 1 1/2 pound density fiberglass material to deaden air noise inside the tubes.

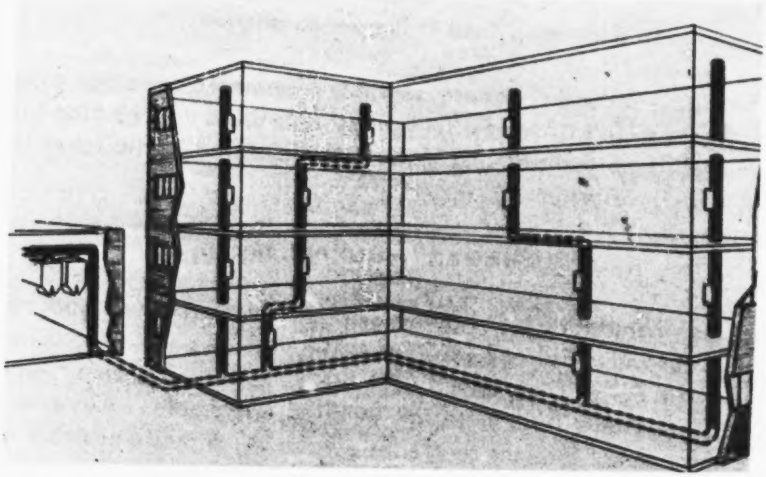
In addition to systems now operating in about fifteen commercial laundries in ten states and one province of Canada, many hospitals have acquired Air-Flyte



a. Inner Door Discharges Load to Pneumatic Chute



b. Discharge from Soiled Linen Hopper to Hamper



c. Schematic Diagram of Air-Flyte Pneumatic Conveyor System in a Hospital

FIGURE II-13

installations. By mid-1969, there were nine operating installations in hospitals across the country and about twenty new hospital installations either on order or being installed.

Some advantages of pneumatic tube conveyors for handling of solid wastes include:

1. Travel can be horizontal or inclined, upward or downward in the same system.
2. Space for intermediate storage of soiled linen and trash has been minimized. Waste deposits can be made by nurses, aides, maids or other personnel as materials are brought to the depository station.
3. An automatic and almost instant method of linen and trash transport to proper storage or processing points is provided.
4. The systems are completely closed, use outside air and are self-cleaning. Contamination risks are greatly reduced as compared with gravity chutes. With the latter, unless under induced negative pressure, air is expelled from the chute door each time it is opened or used.
5. Fire hazard is reduced because on-floor intermediate storage of accumulations of trash and soiled linen is eliminated. Air tubes cannot clog and can be automatically sealed off. No materials are stored in the tubes in the case of the Air-Flyte system.

("Airveyor" - Fuller Company)

Several additional manufacturers of pneumatic conveyors produce bulk material handling systems for industrial applications. The various pneumatic conveying systems made by the Fuller Company, under the general trade name "Airveyor", are representative of available bulk material handling equipment. Airveyor systems may use positive displacement blowers to create a vacuum, provide positive air flow in pipelines, or a combination of vacuum and pressure. Although commonly associated with the chemical and food processing industry, this type of transport has many applications. Installations can be designed to meet specific requirements and to fit into existing structures. A wide range of bulk materials can be handled by this type of pneumatic conveyor. Pneumatic conveying systems of this type may be designed to load or unload, store, weigh, batch or blend. As previously discussed, pneumatic handling of wastes has the advantages of rapid, confined and controllable flows of materials. Pipeline transport minimizes environmental contamination and generally insanitary conditions associated with moving solid wastes. Space and maintenance requirements are less with pipelines than with many other forms of transport.

Conveyor, Roller:

There are two principal types of roller conveyors, gravity roller conveyors which roll freely, and live roller conveyors which have power applied to the rollers. The selection of type depends upon materials to be moved, accumulation requirements, gradients and other factors.

The gravity roller conveyor, as its name indicates, relies upon gravity to move materials from point to point. Materials must be containerized in some manner or be sufficiently massive to move readily from roller to roller for, obviously, loose materials cannot be moved effectively on a roller conveyor. This type of conveyor consists of a pair of side frame members, between which free-running rollers are suspended. The length and width of these conveyors are determined by specific application requirements, although many regular sizes are available from stock. Roller conveyors can be of steel or aluminum. Rollers are available from less than one inch to three inches and in lengths from one to four feet. Roller shafts are fitted with ball bearing races.

The live roller conveyor can be powered by an endless belt, by a continuous chain, or by a series of progressive chains. Curved sections are sometimes powered by V-belts. The belt driven form of roller conveyor can best be described as an endless, flat belt conveyor over which a frame, holding a series of rollers, has been superimposed. The bottoms of the rollers are in contact with the top of the moving belt, which, in turn, imparts reverse movement to the rollers. The belt provides the motive power and rollers function as carriers. The continuous chain roller conveyor, as the name implies, is powered by an endless chain which engages sprockets fixed onto one end of each roller. Progressive chain roller conveyors have two sprockets fixed at the same end of each roller. Two small chains are used to engage the sprockets on each pair of rollers, thus imparting motion progressively from one roller to the next.

This type of drive is sometimes used on long conveyors and where heavy objects are to be moved.

Live roller conveyors are used primarily where accumulation is required or transfer to or from converging lines is desired. They can also be used for short transfer mediums from one type of conveyor to another. They are more expensive than simple belt conveyors and should not be used without the advice of conveyor specialists.

Conveyor, Screw:

Screw conveyors move materials either horizontally, on an incline or vertically. They can be used to feed, distribute, collect or mix certain bulk materials. Dry and moist materials can be handled, but the design and operating speeds of the conveyor will vary and qualified specialists should be consulted.

A typical screw conveyor can be described as a closed trough, usually "U" shaped or may be tubular, in which a longitudinal screw rotates to move materials from one end of the trough to the other. The configuration of the screw will vary with the characteristics of the material to be handled. The rotary motion of the screw is provided by a motor driven assembly attached to the screw shaft at one end of the trough and can be of several types.

Conveyors are available in standard diameters from 4 to 24 inches. Manufacturers advise that virtually every application is unique in one respect or another. For that reason, they urge consultation with engineering specialists before selection of a screw conveyor of a particular size or capacity. Typical capacities vary from about 1.5 cubic feet per minute for a 4" conveyor to about 350 cubic feet per minute for a 24" conveyor with standard pitch screws. A wide range of materials can be handled by the screw conveyor including such items as dry or wet ashes, 3" crushed bauxite, 1/2" crushed bones, coal cinders, corn meal, fly ash, pebble limestone, ground oyster shells, paper pulp, phosphate rock, dry sawdust, granulated furnace slag, wood chips and shavings. Weights of materials handled vary from 5 to 200 pounds per cubic foot. Vertical conveyors, called "Screw-Lift", are available, and can provide practical lifts up to 100 feet. They can handle a wide variety of materials, ranging in density from 4 to 125 pounds per cubic foot.

Conveyor, Slat:

Similar to a flat belt conveyor, this conveyor has two heavy, specially shaped chains operating at the sides of a frame between which wooden or metal slats are suspended.

The slats may be wide or narrow, and the width of the conveyor frame will depend upon the sizes and shapes of loads to be carried.

This type of conveyor is used for objects which are too heavy or otherwise hard to handle on belt, roller or other types of conveyors.

Conveyor, Sorting:

Conveyor systems utilizing special trackage carts and containers with the capability of dumping or otherwise transferring loads to other conveyors are identified for purposes of this report as sorting conveyors.

("Cartrac" - SI Handling Systems, Inc.)

Originally developed in Sweden, where it is used for baggage handling at airports, Cartrac is now being built by SI Handling Systems, Inc. as U. S. licensee. Although warehousing and baggage handling were the first applications of the Cartrac system in Sweden, manufacturing plants in France and England have also made installations and the manufacturers are now considering adaptation of the system for hospital installations in Sweden. The name is an acronym to describe a cart moving on a track. At present, the system can transport loads at speeds of 500 feet per minute and the makers anticipate ultimate speeds of up to 1,000 feet per minute.

A small demonstration loop of Cartrac was observed in operation at the 1969 National Material Handling Show in Detroit. Although limited, the exhibition indicates a variety of applications for a high-speed transporter having some unusual characteristics. As observed at the Detroit demonstration, the system consisted of a loop of track constructed on a metal framework about 18 inches high in a rectangular configuration.

The carts observed in operation on the demonstration trackage were square or rectangular, ranging in size up to about 2'-6" W x 3'-6" L. The platforms were of plastic or metal. The carts were equipped with four wheels on vertical axles on their underside, which rode against the sides of two retaining rails. A drive wheel centered on the underside of each cart is in direct contact with, and rides on top of, a driving tube located in the center of the space between the retaining rails. The drive wheel assembly is capable of being rotated about a vertical axis by contact with longitudinal bars located at approaches to turns or stopping points.

Motive power is supplied to the drive wheel by the driving tube. Driven by small electric motors at both ends, the tube rotates at very high speed. The drive wheel, covered with a rubber-like substance, is in constant contact with the driving tube. The drive wheel assembly has four roller bearing wheels on vertical axes which are clustered about the drive wheel itself. As these rollers come in contact with the longitudinal control bars, they alter the position of the drive wheel with respect to the driving tube. The angle which the drive wheel makes with the driving tube governs the forward speed of the cart. At 90°, the cart will remain stationary since both tube and wheel are revolving on parallel axes at the same speed. Full forward speed of the cart is attained at 45° with lower speeds resulting as the angle increases toward 90°. Carts can be made to retain or change their orientation at corners, as may be required. Retardation and acceleration guides are installed at corners, curves, turns or stops, as may be desired. Despite the high rate of travel, the acceleration and deceleration are claimed to be so smooth that food, including liquids, and fragile loads can be safely transported. The system can be semi or totally automated and equipped with tilting devices for unloading at specified destinations. The manufacturers are now attempting to develop a vertical lift system which can be coupled with Cartrac to provide multistory service.

("SS Sorter" - Speaker Sortation Systems)

Another type of sorting conveyor is made by Speaker Sortation Systems and is known as the SS Sorter. Resembling an endless belt, running in a more-or-less circular loop, the conveyor consists of a series of platforms fastened together in an articulated manner. The platforms or trays can be automatically tilted at any desired station or chute, thus allowing the carried load to be slid or dumped from the platform. Loads can thus be transferred to other belts or trays, standard belt conveyors or other means of transport, or into chutes or bins. The system is semi-automated but requires operators at control panels for programming system activities and tray destinations.

Conveyor, Track, Overhead:

The overhead track conveyor is a slight variation of the overhead chain conveyor as described earlier and has similar capabilities in transporting suspended containers or loads.

("Unibilt" - Jervis B. Webb Company)

The Unibilt overhead track conveyor, made by the Jervis B. Webb Company, consists of an endless chain fitted with double and single wheel assemblies which are universally attached to each other. The assemblies are assembled alternately in the chain (i.e. a unit having two wheels on a horizontal axis is followed by a unit having one wheel on a vertical axis in a continuing sequence). The entire chain moves inside a tubular track having a square sectional shape. The double wheels ride on the bottom or against the top of the inside of the tube, depending upon vertical gradients. The horizontal wheel is in contact with the side walls of the track, guiding the chain around horizontal curves. The design of the chain and track permits the use of compound curves for best alignment requirements.

The bottom of the track is slotted to permit hangers to be attached to and carried from the roller assemblies. The Unibilt conveyor can carry 75 pound loads from each hanger, and the spacing of attachments from which boxes or other containers are suspended is dependent upon the length of each container. Many different types of carriers such as baskets, trays, boxes and special containers can be used. Conveyors of this type normally operate above the heads of workers. Where required to run close to floor level, they can be fenced in. Widths and heights of tunnels or passageways are limited only by the sizes of loads, plus desired clearances.

Conveyor, Tube:

The tube conveyor is an endless pipe within which pushers, connected by rod linkage, are moved in an endless chain to push material inside the pipe from one location to others.

("Tube-Flo" - Jervis B. Webb Company)

In the Tube-Flo conveyor manufactured by Jervis B. Webb Company, linkage rods about six inches long with balls at both ends are connected with flight disc holders forming a universal joint. This enables the entire linkage train to negotiate curves and grades in the tube. The flight discs, which may be of metal or plastic, are placed on the pusher linkage at eight inch centers. The flight discs are free to rotate 360° on the linkage and are attached through an off-center hole. This allows the disc, or pusher, to turn on the linkage and thus move readily following the pipeline contour.

Material is fed into the tube from a hopper and fills the pipe in the spaces between the flight discs. As the linkage moves forward the material is pushed through the tube. Discharge of the material is through one or more openings or spouts in the bottom of the pipe at desired locations.

Tube conveyors can be carried underground, suspended, on the floor or wall, indoors or outside. Nominal tube diameters are from four to twelve inches. Conveyor speeds are from six to sixty feet per minute. Capacities will naturally vary with types and characteristics of the materials carried. At speeds of 60 feet per minute, 2.85 cubic feet of abrasive material can be moved per minute in a 4-inch diameter tube. Lubricating materials, in a 12-inch tube, moving at 60 feet per minute, will have a delivery capacity of 35.4 cubic feet per minute. These estimated capacities are based on 80% of free volume in the tube.

Tube conveyors will handle powders, crystals, flakes, dusts, granules, lumps, sludges, slurries, and metal chips. They may be hot or cold, wet or dry. Such diverse materials as filter cake, lime, fly ash, coal, clay, scrap rubber, graphite, plastics, sawdust, prepared mixes, ground meat, salt, peanuts, detergents, brewing wastes and chocolate can be readily moved.

Tube conveyors work vertically as well as horizontally and can have vertical or horizontal curves and bends incorporated in their design. Being fully enclosed, tube conveyors eliminate the possibility of inside materials or odors escaping and the entrance of outside matter. They can be made fully water and dust tight.

Conveyor, Tube, Belt:

With this method of handling, a belt conveyor runs through a tube when carrying material and returns in an enclosed pan beneath the tube. It is useable indoors or out, reduces dusting, eliminates spillage of materials carried, and will convey a variety of materials.

("Tube-Belt" - Con-Vey International, Inc.)

In the tube enclosed conveyor manufactured by Con-Vey International, Inc., the belts are made about 67% wider than the diameter of the tube, thus providing a trough belt conforming to the contour of the inside of the tube. These conveyors are made in six standard tube diameters: 6", 8", 10", 16", 20" and 30" using belts 10", 12", 16", 24", 32" and 48" wide, respectively. The cylindrical shape of the conveyor lends itself to proper structural support. It can be readily suspended or fastened to walls. The tubes themselves are said to be self-supporting up to twenty foot spans dependent on loading. Tubes are available in stainless or mild steel.

The manufacturer claims that most materials can be satisfactorily handled on slopes of as much as 30°. Materials such as wood chips, sawdust, fertilizer, roofing granules, and sewage sludge have been carried by this type of conveyor.

A low-pressure blower or compressor can be added to inject air under the belt to provide an air-cushion for the belt to ride upon. This is helpful where long systems and heavy loads are involved. Capacities of tube-belt conveyors vary from 8.75 cubic feet in a 6" tube moving at 100 feet per minute to 1,650 cubic feet in a 30" tube at 1,000 feet per minute.

Conveyor, Vertical, Continuous:

Continuous motion vertical conveyors are usually of the pendant tray type. Carriers are suspended between two endless chains moving on gear-like wheels at the top and bottom of a vertical shaft. These carriers are pivoted, and suspended containers remain level during travel. Carriers are generally equipped with fingers which comb through load station fingers as the carriers move upward. Loading takes place on the upside and unloading on the downside and is automatic. Carrier fingers can be manually or mechanically hinged so as to bypass any desired station. Wheel conveyors of variable length are installed at separate loading and unloading stations and may connect with various types of horizontal conveyors in integrated material handling systems.

A similar automated system has been adapted for hospital installations by the Olson Division of Unarco Industries, Inc. This system handles coded containers 16" x 20" x 10" high with loads up to 40 pounds, in shafts as small as 5 x 7 1/2 feet, and at claimed rates as fast as 16 containers per minute, or hourly capacities of about 36,000 pounds. Fully automated injection and ejection of containers have been accomplished in these handling systems, which also have the capability of exchange of materials between stations served by different vertical conveyors.

Conveyor, Vertical, Reciprocating:

Reciprocating vertical lifts such as elevators and dumbwaiters may also be designed to handle special containers or carriers. The dumbwaiter, as manufactured by J. L. Baldwin Co., consists of a line of units capable of handling from 50 to 500 pounds. Cars are available in sizes up to 36" x 36" x 48" high. Power units may be installed at either the top or bottom of the shaft.

Modern elevator controls are frequently employed with vertical conveyors of this type and many are highly automated. In highly sophisticated installations, self-powered vehicles can summon cars, command shaft doors to open and close and direct destinations.

In very simple installations which permit horizontal travel of loads in one direction only, loads are injected from roller, wheel or belt conveyors onto the lift car, the floor of which is a sloping wheel or roller conveyor. The load rolls onto the car by gravity and when the car reaches its destination at another level, the load is released to roll off the lift onto another conveyor.

In general and except for lifts which reach only a few feet or from one floor to another, these installations are customized. Shaft sizes are governed by the sizes of the carts or containers to be moved.

Conveyor, Wheel:

This type of conveyor consists of a series of small wheels, similar to skate wheels, carried on horizontal axes suspended between two side frames. The wheels revolve freely on ball bearings and loads move on them by gravity. Wheel spacing and wheel axle centers will be governed by the sizes, shapes and types of loads to be carried. Wheels are usually made of steel, aluminum or nylon and can be arranged in a variety of patterns. Common diameters are about two inches with a 5/8" face width. Standard conveyor frame widths are 12", 18" and 24". Wheel axle centers are 1 1/2", 3" and 4". Wheel patterns may vary from 6 to 28 wheels per foot of conveyor. Frames are available in 5 and 10 foot standard lengths in the regular widths. Both 45° and 90° curves are also available. One manufacturer makes an automatic pressure conveyor of the wheel type which employs a narrow, endless belt located in the center between the frames and between two sets of axles and wheels. It is used to provide some live, accumulating action to a largely gravity wheel conveyor.

Dolly, Fiber glass, Castered:

These dollies are molded of colored fiber glass. They come in nine stock sizes, ranging from 17-7/8" x 10-5/8" to 42-1/2" x 20" and can be had with four swivel casters or two swivel and two rigid wheels. Wheel diameters are three and four inches.

Standard fiber glass tote pans in sizes from 16" to 39" long, 10" to 19" wide, and 5" to 14" deep will fit on various sizes. The pans are constructed to nest but covers are also available so that pans can be stacked.

Hoist, Container, Rear-Loading:

This heavy duty hoist system is designed to handle large, special-purpose containers, including tanks and bins. It is not to be confused with a mobile packer hoist, with which it has no connection. Container hoists are capable of lifting, transporting and dumping or depositing containers having capacities as large as 15 cubic yards. The equipment can be handled by one man on a truck. This equipment is largely used in industry for handling many types of materials, including loose and compacted wastes.

The "Dempster Dumpster" by Dempster Brothers and the "Load Lugger" by The Heil Co. have many features which are similar although the actual hoisting systems differ. The Dempster hoist is hydraulic and somewhat resembles a forklift mechanism. The Heil hoist is also hydraulic but utilizes a lift, swing and set operation which is affected by a pair of heavy arms which are pivoted at the bottom of the hoist, at chassis level. Both types of hoists are mounted on medium sized truck chassis of relatively short wheel base. They are capable of lifting, transporting, depositing or dumping large, special type containers of a wide variety of styles. Containers having capacities as high as 15 cubic yards can be handled.

Hoist, Tiltframe, Container, Packer:

A tiltframe hoist is designed for attachment to a large truck chassis for the purpose of pulling a large container or body onto the chassis and allowing it to slide off at a desired location. They are used for loading, transporting and unloading the large, closed containers used with stationary packers and also for open-top containers used to haul loose and uncompacted wastes to points of processing or disposal. In its simplest form, the tiltframe hoist is a heavy frame which is attached by a hinge at the rear of the main structural members of a truck chassis. The point of attachment will be about one fifth of the length of the tiltframe from the end which overhangs the chassis. A hydraulic, ram-type lifting device is attached to the chassis and is capable of raising (tilting toward the rear) and lowering the frame and its load. A cable and winch are used to pull the container onto the tilted frame and to restrain it when being unloaded. Hydraulic stabilizing jacks are optional equipment available with most tiltframe hoists. Exclusive of the truck chassis, list prices of tiltframes range from about $5,000 to $7,000.

Packer, Mobile:

The three principal types of mobile packers, front, rear or side-loaders, are identified by the method used to empty wastes from containers into the body. Capacities nominally range from about ten to thirty cubic yards.

The front-loader mobile packer is used for handling large containers rather than as a receiver of loads from hand-emptied cans, as in residential service. The expansion of the use of large containers for the accumulation of industrial commercial refuse has increased the use and popularity of the front-end loader. In addition, the loading and dumping of containers with a front-end loader is somewhat simpler and requires less maneuvering than some loaders of other types. It is possible for one man to load, dump and replace a container. The front-loader packer can be used with container systems for handling such as those used with apartment-size stationary packers and refuse trains. The front-loader packer has an hydraulically operated lifting mechanism usually consisting of a pair of fork arms which can be engaged with the container. The fork arms can be moved forward and backward as well as vertically for engagement of the container. Since the container to be picked up is in front of the truck, the driver has a view of the operation. Some loaders are equipped with a series of mirrors which enable the operator to observe the dumping of the container into the packer - an operation which takes place behind the cab. The lifting operation moves the container, suspended between and held by the fork arms, up and over the cab. The opening into the packer is on top of the body, immediately behind the cab. The hopper cover on the packer body is automatically opened and closed for the dumping cycle. After dumping, the container is replaced on the ground and the lifting fork arms are withdrawn.

The front-loader mobile packer receives its loads of loose waste at the front (topside) and packing action is toward the rear of the body. It is accomplished by a series of compacting movements of a hydraulically operated blade operating inside the body. After a load of loose material is dumped into the hopper of the body, the hydraulic ram is actuated to compact the material and then withdrawn so that succeeding loads may be packed to the rear of the container body. The packer body is equipped with a power operated tailgate which is opened for rear dumping at a disposal or processing site. Dumping is accomplished by the packing blade pushing the entire load out of the body through the open tailgate.

The rear-loader is perhaps the most widely used of mobile packers in residential waste collection, where cans of refuse are manually dumped into a packer hopper. Some models of this type are or can be equipped with hoist mechanisms for handling and dumping the contents of large containers into the packer hopper or body. One manufacturer (Leach Company, Oshkosh, Wisconsin) features a combined packer and carrier plate having an "L" shaped cross section. As it moves forward, the bottom section pushes the loose waste upward while the upper portion pushes it toward the front of the body. At the same time, the pushout plate moves toward the rear of the body producing a compressive action, which is claimed by the manufacturer to create a compaction density of up to 1,000 pounds per cubic yard on dry household refuse.

A rear-loading packer body is generally emptied by raising the entire rear hopper and loading mechanism while the pushout blade forces the compacted load out of the rear of the body. These packers are made in a range of sizes from about sixteen to twenty-five cubic yards. A thirty-one cubic yard semi-trailer type is also available. It has its own self-contained power supply system for full operation.

Side-loading packers are produced in models generally ranging from 13 to 28 cubic yard capacities. Loading is accomplished through an opening on the side, near the front of the body. Cans may be manually emptied into this opening which, when not in use, is covered by a sliding door. Some models are equipped with a container hoist which lifts special containers up the side of the packer body and empties the contents into the body just behind the cab. The side-loading packer body is emptied by raising the rear tailgate while the compaction blade is used to evacuate the compacted load from the body.

Packer, Trailer:

Dempster Brothers, Inc. make and market a very large compaction trailer, which is a complete packer and container mounted on a semi-trailer. These packers can be used in place of a stationary packer and/or a transfer trailer at a transfer station. Two sizes are available - 65 and 75 cubic yards. The trailer, with its compaction unit, is 39 feet long, 8 feet wide and from 12 to 13 feet high, depending upon the model. The hoppers of the two models will hold 16 and 19 cubic yards respectively. Gross weight of the vehicles is about 13 tons. The hopper opening is in the top of the box and is 100" x 88" in size. Materials can be dumped from other trucks or packers or chuted into the hopper of the trailer. Packing action is from front to rear. An 85,000 pound thrust is claimed. At the disposal site, the rear tailgate of the trailer is opened and the load is pushed out through the rear.

Val-Jac Manufacturing Co., Inc. and others make small, towable packers. These trailer compaction units may be rear or side-loaders and are useable around building complexes. They are manually loaded and are commonly rated at 10 cubic yards. The manufacturer claims compaction to 600 pounds per cubic yard for the Pak-Rat-Pup, a self-powered packer on a trailer.

Scooter, Collection, Trash:

Cushman Motors markets a small three wheeled refuse collection vehicle. Behind the driver's cab is a tiltable, open body with a capacity of about 1 1/4 cubic yard. The body is tilted toward the rear by a hydraulically operated ram-type mechanism. Ease of operation and excellent maneuverability are prime sales points made by the manufacturers. The vehicle has a 72" wheel base, maximum overall length of 129", and a turning radius of 15 feet. The vehicle is useful around grounds and as a small capacity satellite for larger collection vehicles.

Tractor, Electric, Driverless, Self-powered:

The driverless tractor systems have some features and capabilities similar to the self-powered driverless electric carts previously discussed. The driverless tractor, although primarily designed for driverless operation, may also accommodate a driver for movements remote from the guidance towpath, which is normally used to control the vehicle when unattended.

("Prontow" - Jervis B. Webb Co.)

The Prontow driverless tractor manufactured by Jervis B. Webb Company has three optional guidance systems - magnetic, optical or radio controlled. Magnetic guidance is accomplished by means of a low-frequency excited guide wire placed in a shallow groove cut in the floor. Right and left hand sensing coils on the tractor detect the magnetic field generated by the wire and pivot with the steerable wheel. A signal level detector permits operation only when signal strength is sufficient for guidance. The traction motor will not operate without sufficient signal strength.

In optical guidance, the towpath is a line contrasting in color to the floor. The line can be either painted or laid down in the form of pressure-sensitive tape. Light-sensing elements on the tractor distinguish the difference between the color of the floor and the contrasting color of the paint or tape. The information provided by the light-sensing elements is evaluated for level difference and steering signals sent in much the same way as in magnetic guidance. A safety condition is recognized for both all dark or all light surfaces, such as the end of a tape or a white newspaper over the tape. When such a condition occurs, the tractor immediately stops and remains stopped until put back in operation by a human operator.

Guidance by radio control allows movement of the tractor to be continually controlled by an operator in a remote location. A compact, transistorized radio transmitter with rechargeable batteries is provided for the operator. The tractor will move forward, steer right or left, as long as the transmitter is operating and will brake to a stop when transmission stops.

Systems can be either very simple or complex and can include block signals and predetermined patterns of movement, including switching. Several models of this tractor are available. They vary in maximum drawbar pull from 750 pounds to 2,500 pounds. Overall dimensions of these tractors vary but they are as large as 86" long x 42" wide. The manufacturer claims the tractor will operate in four foot aisles but required space will be governed by the widths of carts and loads being towed. They will operate in seven feet of headroom. Weights with batteries will vary from 2,700 to 3,900 pounds.

Trailer, Transfer:

Unlike packer trailers, which have packers integrally built on them, the compacting of wastes into the transfer trailer is accomplished at a transfer station by a fixed packer installed there. Wastes are hauled to the transfer station by mobile packers or other collection vehicles. Their loads are dumped into the hopper of the fixed packer which compacts the materials into the large transfer trailer body. When the body is full, it is hauled by a tractor to a disposal or processing site. A hydraulically operated ejector plate pushes the waste materials out of the rear of the transfer trailer, which is equipped with a full-opening tailgate. The trailers are available in 65 and 75 cubic yard capacities and are about 39 feet long, 8 feet wide and have a maximum height of about 13 feet.

A transfer trailer which empties from the side has recently been introduced. When hydraulically tilted, the entire hinged side opens, thus allowing the contents to slide out sideways without the need for a hydraulic or mechanical ejection plate.

Train, Container:

The container train manufactured by LoDal, Inc. consists of a series of castered containers equipped with coupling devices which enable them to be towed by a tractor or other small vehicle. The containers, of one cubic yard capacity, can be spotted throughout a building complex for receiving waste materials. They can be periodically hauled in a train to a central point where they can be emptied of their contents. The containers are equipped with special lifting channels which match the front-loader mobile packers made by the same manufacturer. Other and larger containers can also be fitted with tow hitches which would enable them to be coupled into a train of containers or carts.

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Storage of wastes for purposes of this report has been previously defined as the interim containment of accumulated materials in either loose, compacted or other processed form prior to subsequent handling, processing or disposal.

Storage as related to solid wastes further includes required facilities for the containment of both reusable materials (such as soiled linens) and disposable wastes. However, this section of the study is primarily concerned with the problems associated with disposables. Characteristics of these materials subject to storage may range from loose, mixed or segregated wastes (including rubbish, food wastes, sharps, pathological, and non-combustible materials) to various types of processed wastes (including shredded, baled, compacted and pulped materials).

Containment of loose wastes may be accomplished with various types of accessories for dry storage, such as bags, wastebaskets, barrels, bins, etc. in either its bulk state as collected or after undergoing certain dry processes such as shredding, pulverizing, which achieve a substantial degree in volume reduction and produce a homogeneous end product.

Other methods of volume reduction may be accomplished with various types of compaction devices, such as packers and balers. These dry compaction processes may handle both loose bulk wastes or shredded or pulverized wastes. Conventional containment of these materials is by compaction in special bins, containers and in some cases standard cans and paper bags. In the case of some balers, the compacted wastes are merely strapped for open storage.

Certain reduction processes involving both grinding or shredding and compression, together with the addition of a small amount of moisture, produce a moist homogeneous compacted waste in an extruded form. Storage accessories for this end product are similar to those for loose wastes, although the volume requirements are considerably reduced.

The pulping process, in which loose or bagged dry wastes are greatly reduced in particle size by grinding and shearing action in the presence of water, produces a slurried wet waste. The liquid slurry can either be transported through pipelines for further treatment or passed through a dewatering press. In the latter case, the end product is a damp, uncompressed sludge of high moisture content and high density. Storage requirements may be limited to barrels or special containers where larger volumes are involved.

Storage and handling are inextricably related. The wastebasket, the simplest form of a storage unit, must be emptied, usually into a larger receptacle, which, in turn, is another storage unit. The emptying process and the movement of both the wastebasket and the larger receptacle are elements of the handling process. The large waste receptacle is moved, usually on a manually pushed cart to a terminal point on the floor. If, when the cart reaches this destination, the accumulated and presumably bagged waste was deposited in a chute or other handling device, no further interim storage space need have been provided on the floor for waste accumulations. What is perhaps more important, one entire handling operation would have been eliminated.

The foregoing is not against the provision of necessary storage areas. It is in favor of reducing the tendency in institutions to use storage areas for the avoidance of work by some and creating work by leaving items for others to rehandle. It favors the elimination of any unrequired operations, especially the most expensive of all, manual tasks. Storage areas are highly essential but they should be planned in conjunction with the actual requirements of the handling system, for both functions are inseparable.

Waste storage facilities must include the various types of temporary storage receptacles, such as bags, baskets, barrels, packer containers and bins, etc., but also the properly planned storage areas, rooms or spaces in which the equipment will be used and handled. These areas must be carefully located within individual rooms, departments, utility stations and on the ground floor or basement service levels as well. If stationary packers are to be used, ample horizontal and vertical clearance must be provided to permit the movement of loading equipment. Provision must be made for adequate cleaning and sterilizing of the waste storage areas, as well as equipment and receptacles.

It is recognized that despite the need for the reduction of the numbers of storage points, adequate spaces must be provided within the Unit, Inter-Unit and Inter-Building systems. No amount of desire will eliminate the necessity for properly planned, well laid out and adequately sized storage areas within the total solid waste system.

In planning storage areas, the volumes and compositions of the generated wastes must be known or estimated with reasonable accuracy. The total handling concept must be determined as well as methods of processing and disposal before the number, sizes and locations of the storage areas and the required equipment can be determined.

Review of Storage Methods and Equipment:

The review of methods and equipment as contained herein covers the limited specialized components available for the storage of wastes, as well as numerous accessories employed for this function.

For purposes of this report, these equipment classifications were established by definitions, as appear in Appendix "C". A product list, Appendix "D", was also prepared providing the alphabetical listing of the equipment classification, together with a partial listing of the respective manufacturers and trade names.

The following narrative review of equipment covers selected categories of equipment and accessories, with general discussions on their application in the waste system.

Bag, Laundry, Soluble:

Although developed primarily for control of the spread of infection and contamination in the handling and reprocessing of soiled linens in hospitals, these bags may have other applications. They are made of polyvinyl alcohol film and are readily soluble in 140° water. Initial deterioration begins even in cold water. The bags are made in four sizes - from 17" x 22" for diapers to 34" x 44" for large hamper liners. The standard bag is 26" x 36". Known as "room size", it will hold 25 pounds of linen. The manufacturer claims satisfactory chute drop tests as high as ten stories. Prices of the bags listed above are: diaper size 14¢, room size 23¢, and the large hamper size 34¢.

Bag, Paper, Disposable:

Paper bags are made in various combinations of sizes and resistance to moisture. Two of the standard sizes are 20 gallons and 30 gallons. Standard type bags are used for moist and dry refuse; leak resistant bags are coated with a polyethylene moisture barrier on the inner ply and are used in dietary areas, lunchrooms, near vending machine loactions, etc. The bags claimed by the manufacturer to be leak-proof are made of two plys of high wet strength paper with the inner ply polyethylene coated, as in the leak resistant bag, but with a special leak-proof bottom closure. Some makes are treated with bacteriostatic chemicals to resist and retard the growth of bacteria and gems. Prices range between $12 and $20 per hundred, depending upon capacity and degree of resistance to leaks. Various types of holders have been developed by manufacturers for use with bag storage systems, including open tubular stands, wall mounted frames and enclosed cabinet style models. Prices of these accessory holders will generally range from $10 to $35 per unit depending on type, size and features.

Bag, Plastic, Disposable:

Bags are commonly made of polyethylene but some of them are combinations of polyethylene and buta diene rubber, of varying thicknesses, usually 0.00125" gauge, and colors. Capacities will vary from 3 1/2 to 55 gallons. Bags of this type are commonly used as liners for waste cans. The larger sizes are made of heavier gauge material. Prices may range from $19.50 to $190.00 per thousand, depending upon capacity and the thickness of the bag material.

Barrel:

Utility barrels are produced in aluminum, fiber, plastic, and steel, ranging in capacity from about 20 to 65 gallons.

Aluminum barrels are made in sizes from 33 to 50 gallons and weigh between 12 and 15 pounds. Fiber barrels are made in sizes from 18" x 30" to 24" x 48", with or without casters and can be had with tops. These units are constructed of heavy case-hardened fiber, riveted at seams and reinforced with corrosion resistant steel rims, bottoms and hand holes, if any. Shapes, other than cylindrical, such as half-round, rectangular, round corner, etc. are available. Plastic barrels are available from several manufacturers in sizes from 20 to 65 gallons, with or without handles, in colors for coding purposes, and in a variety of gauges. Dome or other special styles of tops are available. These units are generally made of polyethylene or copolymer plastic. Prices vary with quality but range between $11 and $18 each for the 32 gallon size.

The steel barrel or drum, although heavier than barrels of other materials, has advantages of great durability. These units are available with open heads and covers.

Box, Tote:

Tote boxes are produced in aluminum, fiber, fiber glass, plastic and steel. Aluminum tote boxes, although usually associated with conveying systems, are also used for temporary storage of small quantities of waste materials or articles to be reprocessed. They are available in common sizes: 34" x 17" x 12"; 21" x 18" x 7" and 21" x 16" x 5". Fiber and fiber glass tote boxes are made of heavy, hardened fiber and edged with metal, and are made in a variety of sizes. They are available in stacking or nesting shapes. Plastic tote boxes are available in a multiplicity of shapes and sizes, with flat, square or rolled flanges in a variety of colors and standard lengths to 24", widths to 18" and depths to 14".

Steel tote boxes of limited styles and sizes are available for heavy duty applications where lighter weight boxes previously described are not suitable.

Cart, Hand-pushed:

Carts are utilized in both storage and handling functions but have been included in this chapter on storage for purposes of this report.

Many styles are available from the simple two-wheeled hand-truck for moving barrels to special purpose designs. Units are often manufactured with steel or aluminum frames and special purpose bodies are produced in aluminum, fiber glass, fiber and stainless steel. Hamper-type carts of various sizes are also available with or without casters or bottom drain assemblies. Fiber glass carts or trucks are of the hamper or tub styles. Molded in one piece, of fiber glass reinforced polyester, they have smooth and seamless surfaces. They are non-rusting and are easily cleaned. The lined styles have no bacteria or dirt-harboring cracks or creyices. Unlined carts range in sizes from 36" x 26" x 27" deep to 60" x 39" x 32" deep. Carts with liners are sized from 36" x 24" x 26" deep to 39" x 28" x 30" deep. The bodies of fiber carts are made of .080" to .090" thick vulcanized fiber. The sides, corners and bottoms are reinforced with specially shaped steel bands which also act as bumpers. Bottoms are of hardwood. Although generally of the open-top, hamper style, many other designs are available. Generally, the carts have fixed wheels but are available with casters. Steel carts are available in more styles and designs than in any other material. Combinations of steel plate, strips, angles or wire are among the standard models. They can also be had in closed sides and top varieties.

Cart, Packer, Stationary:

A heavy-duty, steel box used with a special dumping device attached to a large stationary packer. This cart is castered and is drawn or pushed by some type of towing unit and can be coupled to similar carts and made into a train. Its capacity is four cubic yards.

Cart, Refuse, Tiltable, Plastic:

The hand-pushed tilting carts are very durable and have many applications. Equipped with two rubber-tired wheels and a rear caster, they can be readily pushed, even though capable of carrying heavy loads. They are molded of seamless, chemically-strengthened plastic and reinforced with square tubular steel outside framing. Hinged lids are optional. The manufacturer claims that these units may be cleaned with chemical solvents or steam. Designed to carry from one half to one cubic yard of material, either dry or wet, they are said to be capable of handling loadings of from 800 to 1800 pounds. Overall dimensions range up to 65" L x 35" W x 42" H. Weights of the tilt trucks vary from 130 to 168 pounds. The half cubic yard model is priced at $135 and the largest one cubic yard model, 1800 pounds, is priced at $200.

Cart, Side-Loader, Packer, Mobile:

This is a small, aluminum, open-top cart designed for use with a special side-loader, mobile packer. It will hold 5/8 cubic yard. Equipped with two pneumatic-tired wheels and a caster, it can be easily hand pushed. Empty, the cart weighs 75 pounds.

Container, Packer, Mobile:

Containers used with mobile packers vary in sizes, shapes and styles depending upon the type of packer they are to be used with, the manner of dumping, and the manufacturer. The three general classifications of mobile packers, front-loader, rear-loader, and side-loader require containers of differing characteristics and these are identified by the same descriptive nomenclature. Containers having from one to six yard capacities are in general use. Some special, industrial styles are somewhat shallow pan-shaped and may hold up to 12 or 15 cubic yards. The mobile packers which handle and dump these containers are equipped with special hoists and their several methods of use are described in detail below.

This class of container is made by many different manufacturers and used with a variety of front-loading packers. The descriptions and comments that follow are general in nature and represent a somewhat composite picture of available equipment. Generally, rectangular in shape and holding from one to eight or, in some cases, ten cubic yards, these containers are intended for the temporary storage of loose wastes. They may be chute-loaded under certain conditions but are usually filled by hand or from hand-pushed carts. They are commonly placed on the ground and left in such a position that packers may be easily maneuvered into position for the pickup of the container by the trucks' loading mechanism. They are used extensively as parts of store, shopping center, apartment and institutional waste collecting systems. The pickup and emptying operations are handled by municipal or private hauling contractors' crews. After emptying into the mobile packer, the container is replaced on the ground for reuse.

Containers are equipped with hinged covers to prevent deposited refuse from being scattered by the wind. Some covers are spring-loaded. The smaller sizes of containers are usually castered to allow for hand-pushing. This is especially so where they are for use inside buildings where headroom and/or other clearances will not allow trucks to reach the usual locations of the containers. Where loading docks are available, the larger sizes of containers are feasible. They can be placed on the ground and loading from hand-pushed carts can be accomplished from the dock level.

The designs of loading lugs and container shapes vary with the different manufacturers. In general, the lifting mechanism is a forked arrangement and requires matching slots or holders on the sides of the containers.

Front-loader packers, and hence the containers used with them, have the advantage of requiring less handling labor since the truck driver has a much better view of the container to be lifted than he does with rear-loader packers. Front-loaders can be operated by a driver and helper and, in emergencies, by the driver alone. Rear-loaders require a minimum of two men and commonly three make up a crew.

Prices of these containers will vary, depending upon design, weight and corresponding delivery costs. However, they will generally be found in the following range: 1 CY @ $150, 2 CY @ $195, 3 CY @ $245, 4 CY @ $275, 5 CY @ $320, 6 CY @ $345, and 8 CY @ $415.

There are fewer rear-loaders which are designed to handle containers than there are front loaders and hence there are a limited number of sizes and styles of rear-loading packer containers available. Shapes vary from generally rectangular, with sloping fronts for smaller containers, to large, somewhat shallow, pan-styles on the 10-15 yard sizes. Like the front-loader containers, these are equipped with hinged tops, some being spring-loaded. The smaller sizes are usually caster-mounted.

The side-loading packer container serves in much the same manner as does the front-loader container. Two general styles are common. One has a flat top while the other is slightly peaked. Both are equipped with lids. Sizes range from 1 1/2 to 4 cubic yard capacities. Containers are castered and the manufacturer claims ease of handling and spotting. Weights of empty containers range from about 300 to 600 pounds.

Container, Open-top, Roll-off:

Built of heavy steel, substantially reinforced, these containers are designed for the mechanical dumping of loose wastes and very large, generally non-compactible objects. They are frequently used in connection with self-dumping hoppers handled by forklifts.

Capacities of these containers range from six to forty or more cubic yards. Overall widths are about eight feet. Heights vary from three to eight feet. Lengths run between 17 to 21 feet.

These big boxes are handled onto and off truck chassis by tiltframe hoists of various designs. Dumping the contents of the container is accomplished by raising the box and opening its rear doors.

Prices on the largest size are not available but $400 for the 10 yard size and $700 for the 20 yard container will provide some basis for estimates.

Container, Rear-Loading:

These containers differ greatly from those used with mobile packers and are not to be confused with them. These units are large, special-purpose containers, frequently used in industry. Open-topped, tank type and other styles of closed containers are available. They are equipped with special lifting ears or lugs and can be handled only by the special hoists (described in Chapter II, under the heading: Hoist, Container, Rear-Loading.) The rear-loading container is lifted by the special hoist, which is usually mounted on a short-wheel base heavy duty truck chassis. It can then be transported and subsequently deposited or dumped at a disposal site. Containers are generally of two basic types - tilt and skip, or bottom dump. In addition to styles already mentioned, hopper, sludge and pallet styles are available. Although, as previously mentioned, these containers are used in industry for hauling bulk materials, they have applications for moving wastes around building complexes and can be chute or mechanically loaded.

Container, Receiving, Packer, Stationary:

Unlike containers used with mobile packers, of which there are a variety of shapes, those used with stationary packers are more uniform in general configuration. These containers, generally box-like in appearance, usually have an opening in the lower half of one end of the box to allow the packer ram to operate inside the container during the compaction cycle. This loading end is also hinged as a tailgate to permit it to swing fully open for the dumping of refuse from the container at the point of disposal. The container is equipped with a pair of cables which are used to retain the compacted load during transport to the disposal area.

The stationary packer is equipped with a ratchet locking device used to secure the container to the packer during the filling and compacting operations. When the container is full, the ram has been entirely withdrawn and the retaining cables or tubes and the tarpaulin are in place, the full container is winched onto a tilt-frame hoist and can be carted away. The full container is replaced by an empty one, which is strapped or locked to the packer and the entire unit is again ready for operation. The sides and top of the container are tapered slightly to facilitate refuse slideout when dumping. The following data will provide indicators on the price range of the various sizes of containers available.

Capacity	Length	Approx. Price
27 CY	16 feet	$3,000
30 CY	18 feet	3,100
37 CY	20 feet	3,400
42 CY	22 feet	3,500

Hopper, Feeder, Vacuum:

These air-operated devices can be incorporated in pneumatic conveying systems and are designed for transferring materials from bulk bins, or shipping containers, into processing machinery or from one process to another. Units are positioned over equipment to be charged, such as mixers, blenders or reactors. Materials are drawn into the hopper feeder under vacuum produced by a jet-air venturi suction valve. The complete system is under negative pressure.

The manufacturer claims feed rates to 1000 pounds per hour and, under some conditions, handling of ground or shredded materials having densities up to 300 pounds per cubic foot. Hopper sizes are small, varying from 1/4 cubic foot to four cubic feet. Material pickup hoses are 1 1/2 inches in diameter. Overall dimensions of the feeder are about those of a three foot chute.

Hopper, Self-dumping:

Built on structural steel bases, these open-top hoppers are designed with a latching lever which holds the hopper in an upright position during filling and transport cycles. Constructed with a hinge pin at the bottom, near the front, the weight of the contained materials will tilt the hopper forward when the latching lever is pulled into the unlocked position. The balance of the weight of the empty hopper is such that it will return to its upright position after dumping. The latch will automatically relock the hopper into its upright, filling position.

The self-dumping hopper can be chute, hand or mechanically fed. Due to its weight, it is normally handled by forklift equipment. These hoppers are available in capacities from 3/8 to 4 cubic yards, varying in size up to 74" L x 83" W x 59" H, and weigh from 440 to 1,480 pounds each. They are optionally available with casters. Approximate price ranges of the various sizes are as follows: 3/8 CY @ $127, 1/2 CY @ $132, 3/4 CY @ $145, 1 CY @ $152, 2 CY @ $221, 3 CY @ $349, and 4 CY @ $391.

Hopper, Vibrating:

Vibrating hoppers are designed to assure a constant flow of stored materials during processing. They do so through the operation of vibratory motors which are integral parts of the hoppers. The manufacturer claims that these hoppers have proved successful against various common storage problems including (1) "classification" i.e. when upon filling the storage bin, the aggregate and fines tend to separate with the larger particles falling to the outside of the bin, (2) "selectivity" i.e. when the design of the bin causes it to discharge the center portion of the material first and the outside walls last. This is also referred to as coring or rat-holing, and (3) "bridging" i.e. when a flowable material is rendered unflowable by one of five common causes (adhesion to walls or cohesion of particles, irregular particle structure-interlocking, set factor, static pressures and dynamic pressures). This type of live bottom hopper is designed to provide a steady, continuous, controllable flow of materials from storage, on demand. Vibrating hoppers are available in light or heavy duty models and with capacities varying from 25 to 100 tons per hour.

Hopper, Weighing, Air-operated:

This is a device, incorporating a scale, used in conjunction with the feeder hopper just described. It does not change the capacities or rates of handling of the hopper but allows automatic weighing and discharge of batches of dry bulk materials. The weighing and discharge cycles can be made automatic or be manually controlled.

Washer, Can:

Two basic types of waste can washers are available. One is a device to wash cans or other large containers after the contents have been emptied completely. The second type combines a can washer with a heavy duty food grinder or disposal unit. The better grades of this equipment are made with cabinet enclosures to limit the splashing of water and food wastes and to permit the cleaning of both interior and exterior of cans in one operation. Cans up to 40 gallon capacities can be handled by the cabinet models. Other styles will handle cans up to 25" in diameter or square containers whose diagonal dimensions do not exceed 25". Prices of open style can washers range from $235 to $550, the cabinet models at about $600, and the combination food disposer-can washers range from $940 to $1,390.

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During the course of this study, it became increasingly evident that some form of preparation of solid wastes prior to planned disposal is desirable, and under certain conditions is essential. Present practices in disposal operations will not suffice for the changing composition of solid wastes. The need for some preparation of general solid wastes prior to attempted disposal by sanitary landfill or other methods deserves extensive and continuing investigation. Such processes as grinding or shredding permit more material to occupy a given space than is the case with present methods of disposal of raw untreated wastes. In addition, the decomposition of waste materials is hastened by particle size reduction.

Dry grinding of solid wastes prior to incineration or deposit in landfills deserves consideration but alternative methods of disposal should be studied. Reduction by wet grinding or pulping and the creation of a readily transportable slurry constitutes another method which deserves in-depth investigation. A variation of this method involves dewatering of the pulped wastes into a moist sludge for easier handling with less bulk. Although these methods may be considered as means of disposal by the user, they are only processes or preparation of the material for subsequent handling and ultimate disposal.

Processing, as related to this study, includes some operations which are highly interrelated with handling, storage and disposal functions. The criteria used for identification of processing functions is based upon physical change of the loose raw materials. Waste processing is considered as those preparation functions, such as bagging or encapsulating of disposables and reusables, as well as treatments to disposables involving volume reduction through changes in size and shape, uniformity or consistency. The degree of volume reduction and corresponding increase in density varies with the method or combination of methods employed and the composition of the material input. Typical processes or combinations of these processes which precede ultimate disposal may include:

Bagging
Encapsulating
Compaction
Crushing
Shredding
Chipping
Grinding
Pulping
Pulverizing
Dewatering
Baling
Extrusion

Probably the simplest form of processing of solid wastes is packaging. This includes the manual separation of certain wastes and depositing the material in bags or special containers for interim storage until the container is injected into some type of handling system. By bagging, packaging or other encapsulating processes, conditions of the wastes have been changed from loose to contained for greater ease in handling, as well as improvement in sanitation.

Methods or devices which reduce the bulk of solid wastes by compression include such items as balers, crushers and packers. Drastic changes in size, shape and consistency by homogenizing mixed waste materials is another variation in reduction processes employed to facilitate handling, further processing or ultimate disposal. Such equipment as grinders, shredders, pulverizers, and pulpers may accomplish this initial reduction. Further positive reduction may be accomplished by such devices as pelletizers and extruders or dewatering presses in the case of pulped wastes.

Various combinations of equipment components for processing solid wastes are being researched by manufacturers in efforts to develop satisfactory processing or disposal systems. One such combination of components is a pulper having a dewatering press and junk remover as connected processes for reduction of solid waste to a moist sludge form for subsequent disposal in landfills or incineration. Another manufacturer combines a grinder of the hammermill type with an extruding device which reduces solid wastes to highly compressed, moist briquettes. Still another processing system is one which combines a blow hog and a cyclone to combine pneumatic transport of raw and treated materials with a reduction process. The end product is a finely shredded, dry material prepared for incineration or other means of disposal.

The review of equipment as contained herein covers the broad field of specialized equipment and accessories for processing solid wastes as well as certain equipment used in industrial processes that may be adaptable to use in waste processing systems.

Classification of this equipment involved reconciling the wide variations of names and terms used by manufacturers in the processing industries as well as in solid waste management. For purposes of this report, classifications of equipment where considered questionable were established by definition as appear in Appendix "E". A product list, Appendix "F", was also prepared providing an alphabetical listing of the equipment classifications, together with a partial listing of the respective manufacturers and trade names.

The intent of Appendix "E" is to identify by definition all equipment components which might be unknown to the reader or where some degree of confusion would be created if the items were not defined. The product list includes all equipment classifications as defined, as well as other equipment items and accessories where names are self-explanatory.

The following narrative review of equipment covers selected categories of processing equipment with descriptions of the mechanical and operational characteristics and discussions on particular application (or possible application) in solid waste systems.

Baler, Bag-type:

These machines are sometimes called packers by manufacturers but are classified here as balers because they compact waste materials into bags or cans. These units require manual attention when sufficient loose material has been compacted to the limit of the machine's capacity, usually about four cubic feet, compressed. Several variations of this type of equipment are available; however the "Gator" as manufactured by Compaction Equipment Company, Inc. has been selected for discussion of operating principles.

("Gator" - Compaction Equipment Company, Inc.)

The general design of this unit is a horizontal compaction cylinder and ram, the latter acting against a bulkhead. Wastes may be hand or chute fed into a hopper mounted above the compacting mechanism. The ram is actuated by either optical or sonic control instruments, the latter being preferable.

When the capacity of the baler has been reached, an operator opens the bulkhead door and secures a large paper bag over the end of the compaction cylinder. By operating the ram, the slug of compacted wastes is forced into the bag, the ram withdrawn, filled bag removed and sealed and the bulkhead door closed and locked. The baler is then ready for another filling cycle. Alarm systems can be installed to alert an attendant when needed for the removal of the compressed wastes. Filled bags will vary in weight between 55 and 100 pounds, with a compaction ratio of five to one, according to the manufacturer's claims. The manufacturer also claims this baler operates with a 70 p.s.i. pressure on a 15" diameter ram face and has a packing rate of about one cubic yard per minute. The Gator machine is about 10 feet long, 2 feet wide and 2 feet high. The list price of this packer is about $3,000.

Baler, Carousel-type:

The carousel balers are equipped with a circular platform holding suspended bags. Rotation of the platform beneath a receiving hopper aligns bags to be filled either by manual methods or chute. Process may be completely automated except for removal and replacement of bags.

("Loewy-Kompex Machine" - Loewy Machinery Supplies Company, Inc.)

A carousel-type baler, developed in Sweden, is now being made and marketed in this country by Loewy Machinery Supplies Co. under the name of Loewy-Kompex Machine.

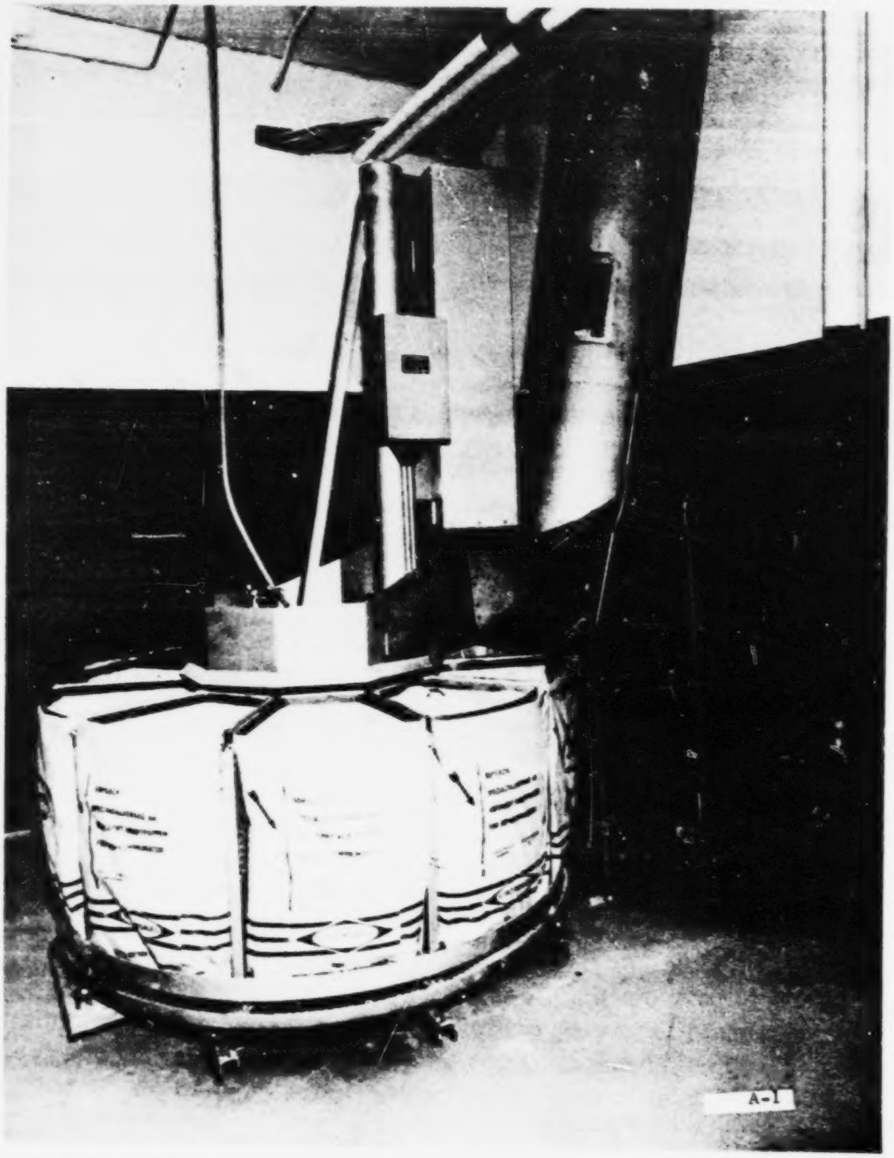
This baler or rotary-type compacting machine features a revolving platform, or carousel, upon which bags can be supported inside retainers and held in open positions. Waste materials can be chute-fed to the baler. As wastes pass optical or sonic controls, and are dropped into an open and unfilled bag, a vertical ram is actuated to compress the materials into the bag. The metal retainer, outside the bag, acts as a restraining bulkhead and prevents the bag from being ruptured by the compaction pressure. The ram is pneumatically operated, a feature claimed by the manufacturer to reduce servicing problems and costs.

When an individual bag is filled to its compacted capacity of about four cubic feet, an automatic indexing mechanism moves the carousel one position which places an empty bag under the ram. An alarm system will alert an attendant so that filled bags can be sealed and removed from the carousel and be replaced with empty ones. Machines having room for thirty bags are said to be obtainable.

Assuming a compaction ratio of four to one, a ten-bag machine should have the total capacity to handle about six cubic yards of loose wastes before manual attention would be needed. By the manufacturer's claims of a higher ratio of compaction perhaps this figure might reach seven cubic yards. Space required for the ten bag machine is equivalent to about a nine foot cube.

("Pak-Trell" - Research-Cottrell, Inc.)

Another carousel-type baler is made by Research-Cottrell, Inc. under the trade name Pak-Trell. This is a hydraulically operated baler having a receiving hopper for chute-fed refuse, two rams (one horizontal and the other vertical), and a carousel-type device for holding filled and empty cans. Bags may be substituted for standard size refuse cans. Two sizes of carousels are available, one capable of handling four cans and a larger one for six cans.



The Ten-Position Loewy-Kompex Carousel or Rotary Type Compacting Machine

FIGURE IV-1

LOEWY-KOMPEX CAROUSEL - LOEWY MACHINERY SUPPLIES CO., INC.

The horizontal ram pushes loose material from the hopper into a half cylinder beneath the vertical ram. This is done in two strokes. After the second stroke, the ram remains in its forward position and forms the wall of the other half of the cylinder under the vertical ram. A hydraulically operated horizontal gate forms the bottom of the vertical cylinder and is closed before wastes are pushed into the vertical cylinder before the horizontal ram is actuated.

After waste materials have been pushed into the cylinder, and while it is being held in place, the vertical ram descends and compresses the material against the closed horizontal bottom gate. Successive loadings by the horizontal ram and compaction by the vertical ram build up a cylindrical slug of wastes 15" in diameter and about 15" high. According to the manufacturer, when this occurs the two rams remain in their extended positions to hold the materials under compaction for an adjustable period of time in order to form the slug of compacted refuse and give the material time to set. Following this prescribed setting time, the bottom gate is opened, the vertical ram extended downward and the slug of compressed wastes is ejected into one of the cans on the carousel.

The manufacturer claims a compaction ratio of five to one and a compacted density of about 25 pounds per cubic foot. It is further claimed that either cans or paper bags can be used interchangeably. The manufacturer states that installation is easy and the unit is readily adaptable to existing chutes and no special piping or wiring is required. A space about 8'-0" L x 3'-6" W x 7'-0" H will accommodate this unit.

Baler, Continuous:

These balers are chute fed and operate horizontally. They are automated except for part of the tying of bales. Designed for industrial use in reclaiming waste paper, chipboard and corrugated board, these units are most efficient when coupled with a hogger which shreds the waste to relatively uniform condition. The application of this type of baler to the processing of general solid wastes cannot be determined categorically. Several factors, all interdependent, must be considered and among the most important of these are the quantities of waste to be handled per day and the ability of a hogger to properly prepare it for baling. The method of ultimate disposal of wastes must also be a determinant.

This class of baling equipment is capable of producing bales having densities ranging roughly from 20 to 50 pounds per cubic foot, depending upon the composition of the shredded material. It is probable that, with proper preparation, shredded materials might be reduced in baled bulk on ratios varying between five and ten to one. Since manual attention is required for bale tying, the attendant labor cost could be prohibitive unless very large quantities of materials were being handled.

Bale lengths can be regulated for automatic cutoff, commonly six feet or less. Widths and heights of bales vary from 24" x 24" to 36" x 40". In order to provide some technical data, the following information was taken from the catalog of one manufacturer, Balemaster Division of East Chicago Machine Tool Corporation. This manufacturer lists 16 models of continuous balers. The smallest unit, equipped with a 10 HP motor, develops a total ram thrust of 35,000 pounds with a 50 p.s.i. pressure at ram face. Overall dimensions of this unit require a space of 16'L x 7'W x 7'H. The gross weight of this small unit is about 7,800 pounds.

Baler, Portable:

These horizontal balers are mounted on casters to permit towing or pushing from one location to another or may be mounted on self-propelled vehicles. They are hand-fed and manually operated. Designed for industrial, commercial and institutional application, they are capable of baling general wastes without special preparation. They produce bales containing from ten to fifteen cubic feet and weighing between 100 and 300 pounds, depending upon the composition of the baled materials. These balers are 10'L x 3'W x 3'H and have a gross weight of 1,650 pounds.

Baler, Stationary:

Stationary balers are commonly of the vertical type. Materials may be fed manually, by chute or by automated conveyors to receiving hoppers or compartments located at the top of the baler. Compaction is by a series of compression strokes of the ram mechanism, which is usually operated hydraulically. Completed bales must be contained or are tied with baling wire, by an attendant. No extensive preparation of materials is made prior to baling.

(Logemann Brothers Company)

Several styles and sizes of stationary balers are manufactured for industrial application by a number of firms as listed in Appendix F. Among these manufacturers, Logemann Brothers Company lists 20 models of vertical downstroke paper balers. Some of the technical data, together with price ranges, follow.

Floor area requirements vary from 8 to 28 square feet and overall height clearances from 8 to 16 feet. Bale sizes range from 30" x 15" x 15" to 72" x 30" x 59" and may weigh from 75 to 1,500 pounds. Platen pressures vary between 2 1/2 to 35 tons. Motors 2 to 10 horsepower may be required.

List prices of balers range through $1,600-$3,500 for the smaller sizes and $2,100-$11,000 for larger capacity machines.

(Apartment-type Baler - Compackager Corporation)

A small stationary baler manufactured by Compackager Corporation was especially designed for use in apartments and institutions having relatively small quantities of wastes per day. These machines will produce bales containing from about five to eight cubic feet of compressed materials. Since the manufacturer claims a compaction ratio of ten to one on general wastes from apartment buildings, each bale might contain the equivalent of from two to three cubic yards of loose materials, when fully compacted. These Compackager balers are small stationary balers of the vertical downstroke type.

The bales must be bound by an operator, using four wires. After securing the baling wires, the bale is enclosed in a large plastic bag, which is sealed to keep in any odors and to reduce arthropod and rodent attraction. Bales can be easily handled by one man with a hand truck.

The balers may be directly hand-loaded or chute-fed. In the latter case, they can be equipped with an alarm system which notifies an attendant when the machine has reached its compacted capacity. Automatic devices are installed so that the baler will operate unattended from its empty to full conditions.

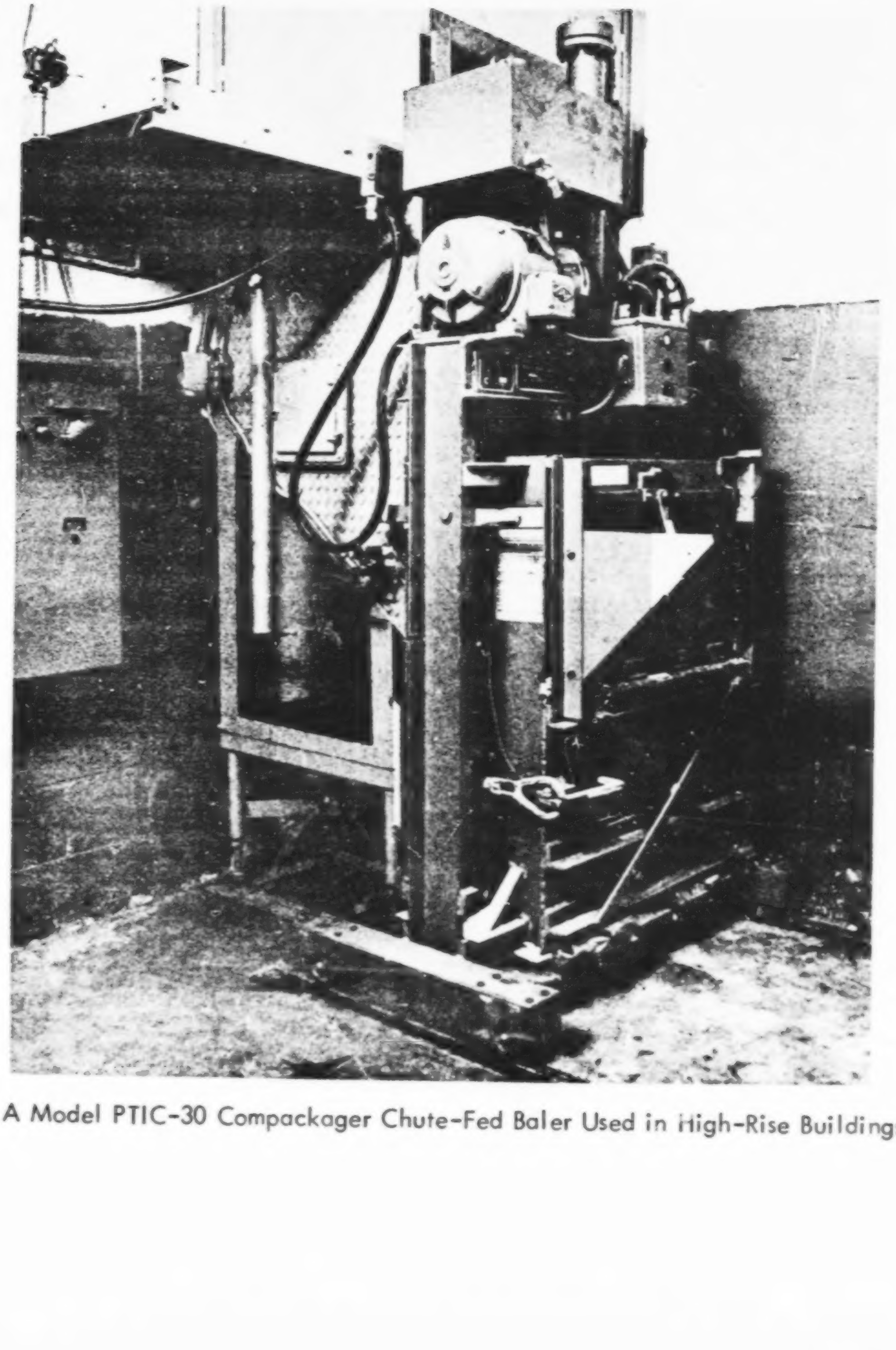
Manually fed models require about ten square feet of floor area with 8 feet of overhead clearance. The semi-automatic, chute-fed models (see photograph) will need about 50 square feet of floor area and 8 feet of overhead clearance.

(Hospital-type Baler - Compackager Corporation)

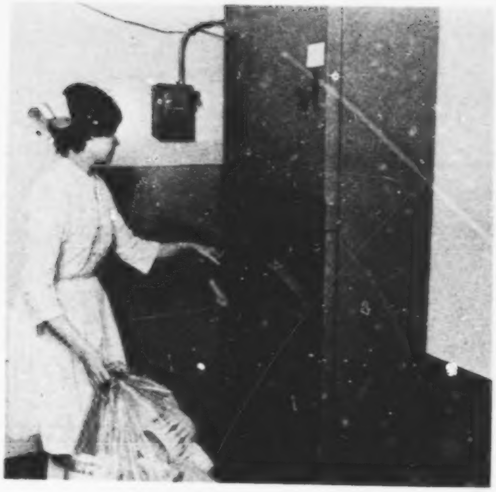
The Compackager Corporation has also developed a baler especially for use in hospitals, garden apartments and nursing homes where several small units may be preferable to a large, chute-fed installation. Installations of this equipment were inspected in institutions in Washington, D.C.

The baler is housed in an attractive cabinet which occupies about four square feet of floor space and stands about seven feet high. A bottom-hinged receiving door is located in the center of the front of the machine. Bagged or loose wastes can be dumped into the receiver, thus providing direct disposal of these materials and eliminating rehandling in a utility room. The operation of the ram actuating mechanism requires the use of two hands, providing adequate safety precautions.

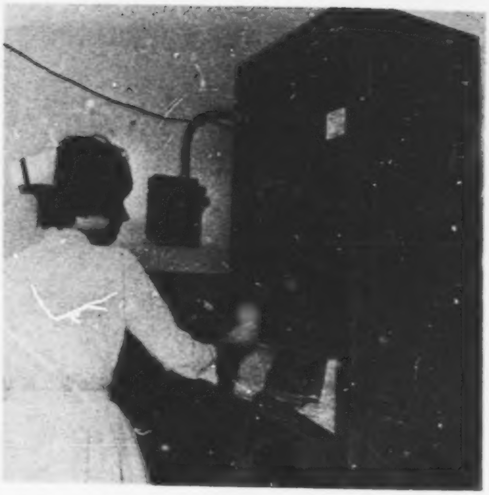
The bottom compartment of the baler has a side-hinged door opening onto the compaction chamber. Before operation, an empty corrugated carton is placed in the chamber. Wastes deposited through the receiving door fall into the carton. When the compaction ram is actuated, it compresses the materials inside the corrugated container. When the box is full and final compaction is completed, the box can be readily removed. It can then be sealed and is easily transported by one man, using a small hand truck. The accompanying photographs illustrate the above noted principles of operation.



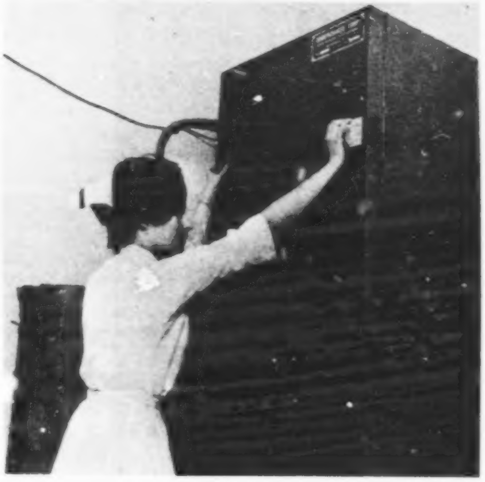
A Model PTIC-30 Compackager Chute-Fed Baler Used in High-Rise Buildings



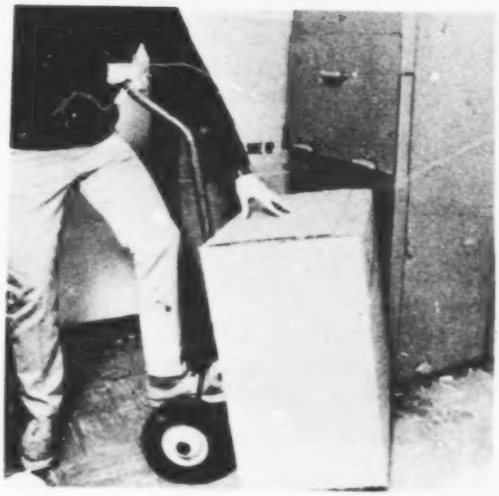
a. Opening Depository Door of Model CA-10 Compackager Unit



b. Depositing Bagged Wastes in Baler



c. Compacting Ram is Activated



d. Removal of Boxed Material from Lower Compartment

FIGURE IV-3

Blender:

This equipment is a type or variety of mixer, generally used in the processing of dry materials, although liquid blenders are also available. Two general types of dry material blenders are common. One is quite similar to a concrete mixer and tumbles the materials from baffles as the drum revolves. The other style, known as a "ribbon" blender, is a cylinder within which a longitudinal shaft revolves. Welded to the shaft are a series of thin, ribbon-like blades formed into an elongated, cylindrical helix.

Drum-type blenders will thoroughly mix or blend dry powders or coarse, lumpy materials. They have capacities from about 5 cubic feet to 450 cubic feet in standard models. They will range in size from 4' x 3 1/2' x 4' high to 21' x 12' x 11' high.

Chipper, Brush:

These machines are designed to reduce brush, tree limbs and cuttings to shredded material by passing the debris through a rapidly revolving drum equipped with cutters. The brush or limbs are hand-fed into a receiving hopper at the back of the machine. The revolving drum pulls the material through the cutters and the resulting shredded wood and leaf particles are blown through an inclined delivery tube into a truck. The chipper is usually towed by the open truck used to haul the shredded materials to a disposal point. Models with 12 and 16 inch wide drums and cutting knives are available. The rotors are driven by heavy duty, industrial type combustion engines at 3000 rpm.

Collector, Dust, Bag-type:

Several varieties of dust collectors are made by the John Zink Co. Of the least complicated is the bag-type, of which there are variations such as shakerless and intermittent types. The basic type forces dust-laden air upward through a series of cylindrical bags. The air passes through the walls of the bags and into the clean air manifold, leaving the dust deposited on the inside surfaces of the bags.

The bags are periodically shaken by pneumatic or electrical mechanical devices. The dust falls into a hopper and is usually removed by a screw conveyor. The shakerless collectors rely upon reverse air flow for cleaning. This type has fewer moving parts. The intermittent collector is similar to the basic type but must be periodically shut down for shaking.

Collector, Dust, Centrifugal:

This type of collector employs a series or clusters of dual vertical cylinders, one inside the other. Dirty air is forced in a downward spiral in the circumferential space between the outer and inner cylinders. The dust is collected in a hopper at the bottom of the cluster, while the cleaned air is exhausted upward through the inner cylinder. The dust is removed from the hopper by air.

Collector, Dust, Cyclone:

These collectors operate on the cyclone principle consisting of a circular outer cone of high velocity air, and an inner column of swirling, rising air. At the lower end of the funnel a partial vacuum exists. The dust-laden air enters the collector tangentially and follows a spiral pattern to the bottom of the cone. The centrifugal action, which forces the heavier dust particles to the periphery of the collector, increases as the velocity increases and the radius of the vortex is reduced. This combination of gravitational and swirling forces causes the dust to move downward to the dust outlet. The cyclone collector has many applications to waste systems and is available in a number of sizes and capacities.

Crusher:

There is no clear-cut distinction which sets a crusher apart from a hammermill, or even a pulverizer. All are generally similar in design, operation and function. The names of these mills are used interchangeably by users and manufacturers. Some degree of differences in the fineness of the end product will exist between crushers and pulverizers but some or all of the basic reduction principles enumerated below are present in crushers, hammermills, pulverizers, impact mills, fragmentizers and shredders.

Some crushers may utilize fixed hammers or swing hammers on a revolving shaft. Others, of the rolling ring type, may employ a series of serrated crushing wheels which revolve loosely about axles attached to circular plates revolving about a horizontal axis. However, most crushers provide multiple stage reduction by a series of actions generally achieved in the following sequence. Material usually enters from the top of the mill. The hammers impact on the falling material and initial size-reduction takes place. Breaker plates located toward the bottom of the mill further reduce the size of the material as it impacts against them. Some crushers have additional plates built into them, sometimes called "anvils", against which the material is forced, thus producing some crushing action between the anvil and hammers. Grids at the bottom section of the mill further aid the crushing action created by the hammers. Materials which have been reduced to maximum allowable sizes will be discharged through the grids. Materials requiring further reduction are flung against the breaker bars at the upper section of the back housing. Remaining material will make the full cycle repeatedly until properly reduced.

Crushers will handle such varied materials as bones, steel turnings, coal, glass, aluminum springs, shells, slag - in general, most friable materials. Capacities will vary greatly with the size of the crusher, the material being processed and the size to which it is to be reduced. Rates vary from 3/4 ton to several hundred tons per hour. Floor space required will range from about 15 square feet to perhaps 150 square feet.

Crusher, Bottle and Can:

These machines come in several models. Some crush only bottles, others flatten cans, while the larger models will handle both bottles and cans. The latter may be equipped with a sloped conveyor to carry the materials to be crushed to the top of the machine. The crushing principle involves the use of three horizontal drums revolving in close proximity to each other. The drums have intermeshing vee-shaped protrusions which force the cans or bottles between the rollers. The manufacturer claims a size reduction ratio of from ten to one. Prices range from about $900 for a small, combination crusher to about $3,300 for a large-capacity machine equipped with a conveyor.

Crusher, Delumper:

This small crusher is used in the food and chemical industries for the further reduction of friables, wet or dry materials. The crusher consisting of a drum with integrally mounted teeth or blades revolves so as to allow the blades to pass through a comb-like screen. The delumper crusher is suitable for size regulation of slurries. Another size reduction device is made by the same manufacturer. It operates on the same general principle but is especially designed with flanges which permit it to be bolted into and made an integral part of a pipeline. Pipeline delumpers are made in standard sizes of 3,4,6,10 and 12 inches. They are constructed of #304 stainless steel. Prices of the 6" and 12" sizes are $3,600 and $9,300 respectively.

Crusher, Syringe:

Similar in principle to bottle and can crushers, this special-purpose crusher, developed for hospital and clinic application, is small and can be table or counter-mounted. Syringes, including needles, are crushed between special rollers. The manufacturer claims reduction to 25% of original bulk. These conventional syringe crushers are priced at less than $200.

Digester, Continuous:

The principal element of the continuous digester system manufactured by Black Clawson Company consists of a tubular retention chamber. A screw conveyor, with variable screw drive, inside the tube, moves pulped material through the tube at a predetermined and controlled rate of speed. The material being processed is digested at the required temperature and steam pressure with accurate control of these variables automatically maintained. The manufacturer claims that pulped materials can be satisfactorily sterilized with this controlled thermal process.

Extruder, Refuse:

These devices are either integral parts of or may be hqd as optional equipment for attachment to certain types of waste grinders. In principle, they compact previously ground or shredded waste materials, which contain some moisture, into a dense briquette. Bulk reduction of loose material, after proper grinding and extrusion, is claimed by the manufacturers to be as high as fifteen to one. This type of equipment, as parts of reduction systems made by Mil-Pac and Electronic Assistance Corp., will be discussed further in conjunction with dry grinders.

Grinder, Dry:

Distinction is made herein between dry grinders and wet grinders wherein the latter require a constant supply of flushing water. The manufacturers of heavy duty lines of dry grinders, crushers, hammermills and shredders produce equipment capable of reducing the sizes of mixed and unselected municipal wastes. In general, the dry grinders selected for discussion grind, crush or shred solid wastes such as are generated in apartments, offices, hospitals or similar institutions. Some have extruders as integral parts of the grinding equipment; others can have extruders added as optional equipment.

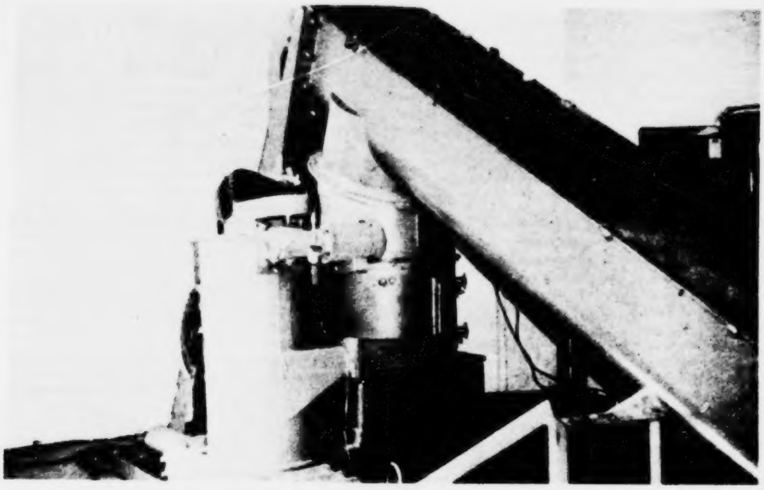
(EAC/Refuse Compactor - Electronic Assistance Corporation)

The manufacturer's brochures on the EAC/Refuse Compactor have been examined but no opportunity has been afforded to inspect the equipment in operation. The EAC machine occupies a space about 5'-6" W x 11'-0" L x 5'-3" H. It consists of a shredder which appears to be of the swing-hammer type, a screw conveyor for feeding the waste from a top hopper into the shredder, and a hydraulic ram for compacting the material into briquettes. The end-product is extruded in compressed form in the form of solid briquettes five and one half inches square in section. The machine can be regulated to cut these off in blocks from four to eight inches long. The manufacturer claims a very high volume reduction of twenty-five to one, and also claims a capacity of 400 to 600 pounds per hour dependent on type and density of refuse being processed. It is further claimed that the equipment is designed to handle general refuse mixture containing plastic and glass containers, metal cans, food waste, sheet metal scrap, wood scrap, rags, paper products, cardboard and light industrial wastes.

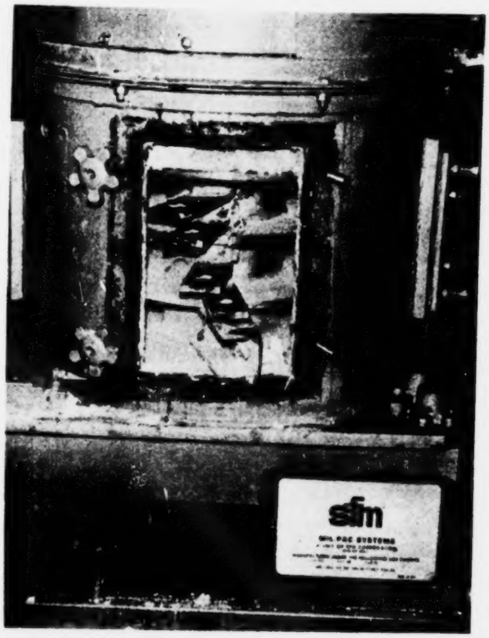
(Mil-Pac - Mil-Pac Systems, Inc.)

The dry grinder produced by Mil-Pac Systems, a unit of SFM Corporation, is, like the EAC equipment, an integrated grinder-extruder. It occupies a space 4'-3" W x 9'-0" L x 8'-0" H including the feed chute. The Mil-Pac consists of a vertical-shaft hammermill for grinding solid waste, which is chute-fed from the top; and a hydraulic ram mechanism for compacting and extruding the ground, moist material. The motorized screw conveyor for the input end, for use instead of a chute, and a sloped output chute are available as optional equipment. The end-product is extruded in five strips of dense briquettes. The briquettes are about four inches square in cross section. The strips are continuous and are pushed along an inclined chute, by the extruding mechanism, and dropped into a container or onto a conveyor. The manufacturer claims a bulk reduction of fifteen to one. The accompanying photographs of the equipment show various features of the Mil-Pac grinder.

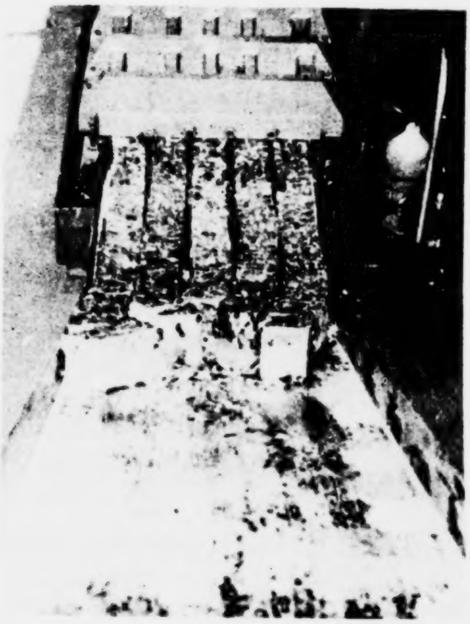
The Mil-Pac, available in three basic models, #2400, #4000 and #6000, have respective rated capacities of 600-1,200 lbs./hr., 2,000-10,000 lbs./hr., and 15,000-30,000 lbs./hr. according to the manufacturer. These capacities are dependent upon the makeup of the garbage and refuse being compacted. List prices of the three models are: #2400 - $17,400; #4000 - $72,000; #6000 - $125,000. These prices are FOB the Union, New Jersey plant of SFM Corporation. It is estimated that the installation costs will be about equal to 20% of the list prices. At the present time only the model #2400 is available. However, the two larger models are expected to be in production by mid to late 1970.



a. Inclined and Enclosed Conveyor at Right Moves Bagged Wastes into Vertical Hammermill

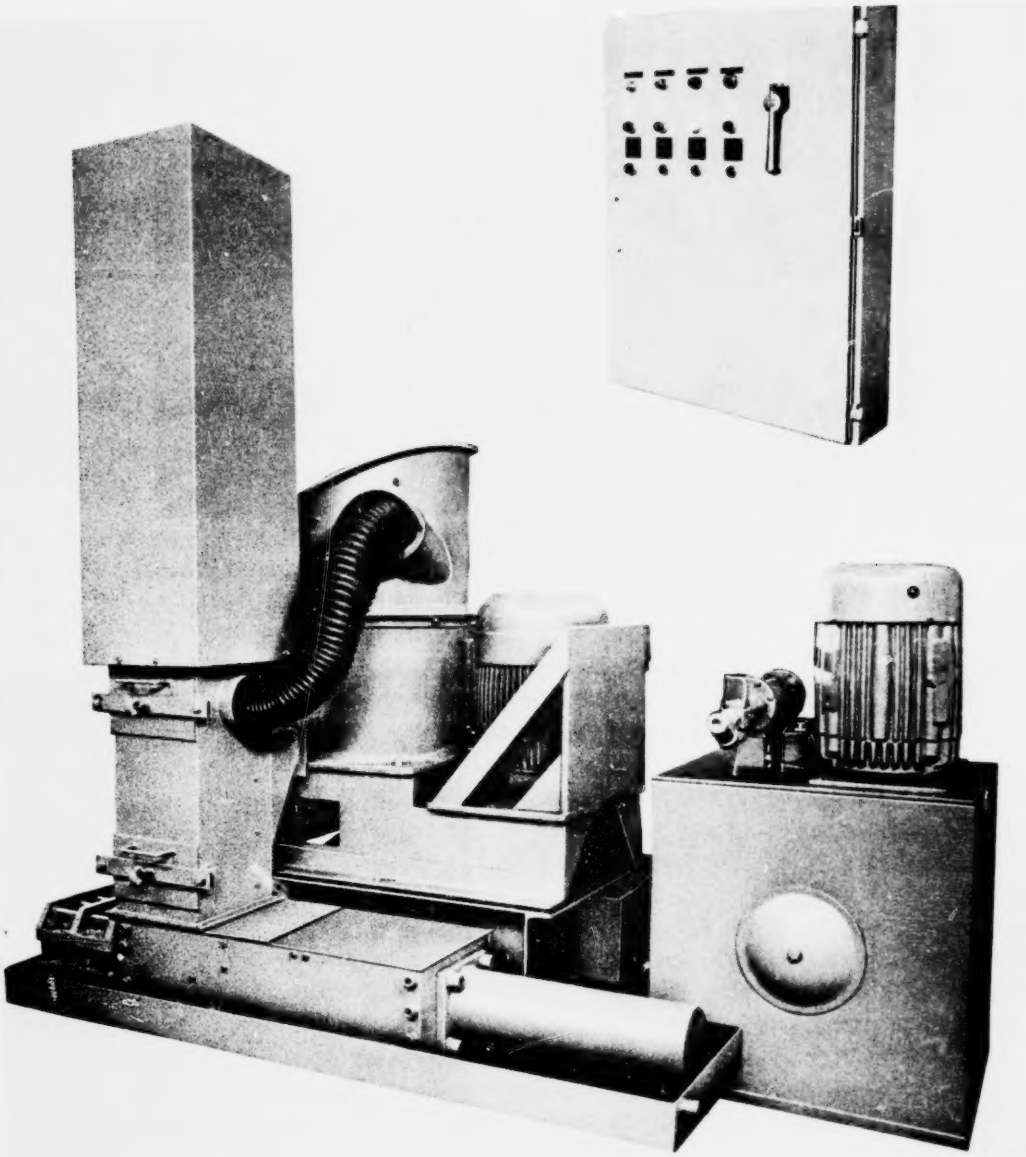


b. Cover Removed Showing Vertical Hammermill



c. Ground and Compacted Wastes Being Extruded

FIGURE IV-4



The MIL-PAC Model 2400 refuse disposal system is designed for hotels, institutions, commercial and industrial buildings, and wherever large amounts of solid waste are generated. It does not cause air pollution because it does not incinerate the refuse. Instead, it pulverizes all solid waste and refuse and compresses the pulverized product into easily disposable briquettes as small as 1/15th its original volume.

FIGURE IV-5

("Mini-Mill" - Eidal International Corporation)

Eidal International developed and manufactures a heavy duty dry grinder whose function is the reduction of automobile bodies, discarded refrigerators and similar oversize bulk wastes. These machines are capable of destroying eighty tons of junked cars per hour, and produce an end-product of scrap metal particles half the size of a man's fist. From Eidal's experience with these large grinders came smaller models, with some modifications. Recently a model identified by trade name as the "Mini-Mill" was developed for the reduction of mixed wastes such as those generated in apartments, hospitals and office buildings.

The first generation of the Mini-Mill has been observed and the results of its grinding of domestic wastes seen at Eidal's plant at Albuquerque. This grinder had two barrels, dual rotors and a rated capacity of three tons per hour of general household refuse or light industrial solid waste matter excluding heavy metal objects and other highly dense materials. The grinder can be arranged for continuous feed by chute or conveyor. A compacting device, identified as a pelletizer, which can compress and extrude the finely ground materials into briquettes, is available as optional equipment. If the pelletizer is not installed, the ground material is discharged into containers or a conveyor. This original model, SW-20, was about 9'-6" L x 4'-0" W x 5'-6" H and priced at about $10,000. The inclusion of the pelletizer brought the total installed cost to about $16,000.

The performance of the SW-20 was quite satisfactory and although users were well-pleased, Eidal developed a newer version of the Mini-Mill. Known as model 75, this grinder is single-barreled and will replace the earlier double-barreled style. The manufacturer claims a capacity of about five tons per hour, with a 75 hp motor. Motors up to 150 hp are optionally available, as are customized feed hoppers and oscillating feed conveyors. The grinder is about 7'-0" L x 5'-0" W x 8'-0" H.

The accompanying photographs show the rotor and side grinding bar plates of the Mini-Mill. It should be noted that the star-shaped grinding wheels are free to rotate about their vertical axes as the rotor assembly revolves at its rated 640 rpm. The rated tip speed is 6,000 feet per minute. The holes in the grinding wheels are larger than the shafts which hold them. This extra clearance produces some hammer action, yet permits the grinding wheel to pass a very dense object without jamming the rotor.

As the photographs show, the barrel slopes inward at the bottom. Materials fed into the grinder, above the rotor, undergo particle size reduction as they move toward the bottom of the barrel. The ground end-product is of coarse texture and, in general, would pass a one inch screen. The quality of the end product will, of course, vary with the characteristics of the input. The soft materials will have been shredded and the friable materials shattered by impact and grinding. The manufacturer claims bulk reduction of the order of six to one. At the time of reporting, no pelletizer was available for the new model.

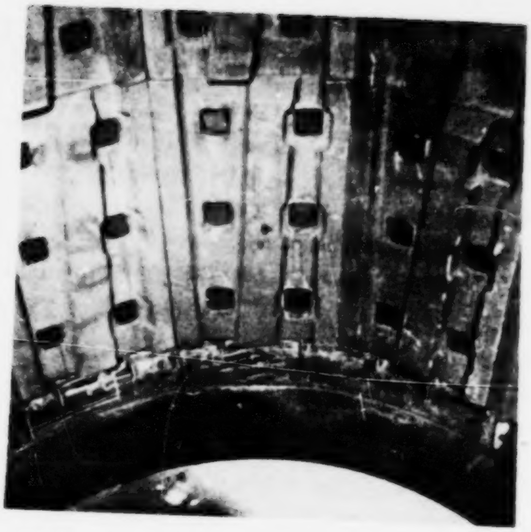
Eidal produces several models of grinders identified as the Mini-Mill (75 hp and 100 hp), the Glutton (200 hp and 400 hp), and the Brute (700 hp and 1000 hp). The Mini-Mill is listed at $11,000 for the 75 hp model and $11,200 for the 100 hp model.

Although relatively new on the market, this grinder has met with the approval of qualified observers who have witnessed demonstrations of its capabilities. These grinders could be used for first stage reduction of unselected wastes where further processing would be carried out or they are suitable for particle size and bulk reduction of wastes which may be the last step before disposal.

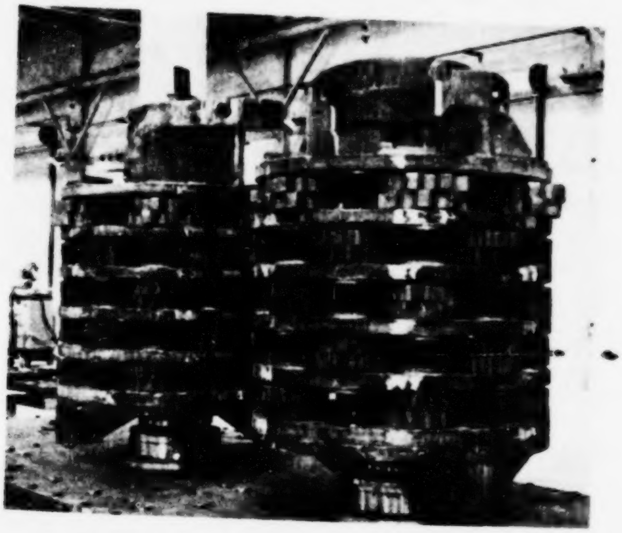
Grinder, Wet:

This class of grinder is of the type usually associated with food waste grinders installed in sinks. They vary in size, capacity and method of installation but all require flushing of wastes into, through and beyond the grinder. They are found in the dietary areas of practically all hospitals, restaurants and institutions which serve food. Although some models are free-standing, most are built into sinks or stripping counters. There are many makes of this type of wet grinder, each having special claims made for it, but all perform the same general tasks - the reduction of general dietary wastes into particle size and condition as to be flushed into a sanitary sewer. Some manufacturers claim abilities to reduce mixed solid wastes. Typical design of these grinders is a vertical barrel set into a sink or receiving bowl. Below the bowl is a grinder and below it is the motor. The ground wastes

a. 75 HP Eidal Single Barrel Mini-Mill



b. View of Grinder Bar Plates on Interior of Grinding Barrel



c. Completed Double Barrel Rotor Assembly Installed on Bed Plate are flushed out of the bottom of the grinder section through a side outlet. Design of the grinding plates differs, but most of the reduction takes place at the periphery of the plates, between the edge of the plate and the serrated ring which forms a portion of the barrel. Some plates feature the addition of small swing-hammers on vertical axes, set on top of the grinding plate.

Sizes and claimed capacities are varied and designations are not uniform. Standard models equipped with motors of 1/3 to 10 horsepower are listed by most manufacturers, and larger models are in the development stage by some makers.

(Atomic Disposer Corporation)

Atomic Disposer Corporation has developed prototypes of wet grinders, utilizing both shearing and slicing actions in addition to grinding, for reduction of hospital wastes and have employed such units in demonstration projects in Los Angeles, California. These units have demonstrated the capability of reduction of various types of plastics (film and rigid), disposable syringes, needles, dressings, etc. to the fineness of grind standards required by the Sanitation Bureau, City of Los Angeles, for discharge to sewers. Advance reports of this demonstration project conducted by the County Health Department, County of Los Angeles, indicate satisfactory results. Total Findings of this study and reports on the performance of this equipment will be available in the near future. Atomic Disposer Corporation utilized both 5 hp and 7 1/2 hp units in this project and since have developed and tested models up to 25 hp.

(Swimquip, Inc.)

Swimquip, Inc., Division of Weil-McClain have developed a prototype of wet grinders claimed suitable for reduction of certain hospital and clinic wastes. It is being developed primarily for the reduction of disposable syringes and needles and other hazardous small wastes generated in medical treatment areas. The pilot model resembling a step-on waste can stands about 24" high and is enclosed in a stainless steel housing with a locking lid.

Hammermills:

Hammermills, grinders, crushers and pulverizers all belong to the same family group. The actions of these mills is to shatter friable materials by impact as opposed to closely grinding them between two harder objects. This has already been pointed out in the discussion of crushers, to which the reader is referred.

The selection of the exact type of mill to use for a specific application should not be undertaken without the aid, and benefit, of the experience of long-established manufacturers of such equipment. The composition of the materials to be destructed, its variations, quantities and other factors will greatly affect the final choice of equipment.

A wide variety of hammermills are available. Some of these are identified as swing-hammer, with heavy hammers pivoted from heavy plates attached to a revolving horizontal shaft; fixed-hammer, which, as the name implies, has its hammers attached rigidly to a plate or other fixture on the main shaft; ring-hammer, with star or somewhat serrated edges and which are loosely fitted on revolving horizontal axes arranged around the peripheries of circular plates; and several modifications of these types.

The interior of hammermill cases are equipped with many variations of anvils, screens and discharge grids, all of which, combined with the velocity imparted to the materials being impacted by the revolving hammers, help to reduce and finally determine maximum sizes of the processed materials.

Hogger:

Similar to the equipment described above, the hogger is classified by some manufacturers and users as a hammermill and may also be correctly classified as shredders. Originally designed to break up wood scraps for further processing, easier disposal or fuel, these mills are frequently referred to as "wood hogs". The predominating design is that of the hammermill, although some hogs are made with knives instead of hammers. The hammer-type hogger is generally classified as knifeless.

(Ecology Industries, Inc., Formerly The Engineer Co.)

The Ecology Industries, Inc. waste reduction system consists of a pneumatic conveying tube, a two-stage attrition device utilizing a blow-hog as the principal destructing device; a cyclone separator and a receiver for the shredded waste materials.

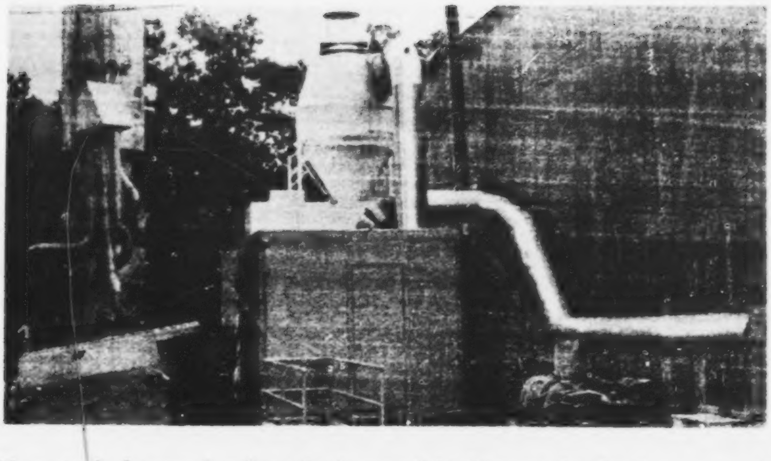
The operation of the Ecology Industries, Inc. pilot plant was observed at the company's plant at South Plainfield, New Jersey. Hospital wastes, in plastic bags, were received from a local hospital, introduced into the pneumatic transport system and conveyed by it through a primary breaker mounted above the blow-hog and then passed through the blow-hog. The latter equipment is located in an underground vault. The pneumatic system carries the shredded wastes through a cyclone separator where all solids are deposited in a mobile packer container for subsequent transfer and disposal. At this pilot plant, the exhaust air from the cyclone is discharged to the atmosphere.

Among the wastes which were included in the observed demonstration were tin cans, aluminum foil, dietary wastes, plastic and glass bottles, paper, waxed milk containers, baby bottles, hypodermic syringes and needles, heavy plastic chemical containers, butane gas bottles, rags and other cloths, and many unidentifiable materials. Following the reduction of this hospital waste and to further demonstrate the ability of the transport and reduction equipment, a bag of short pieces of two inch thick lumber, varying from four to ten inches in width and about two feet long, were put into the pneumatic tube receiving hopper. As observed at the discharge end, this material was reduced to splinters, slivers and coarse particles, none being longer than three inches.

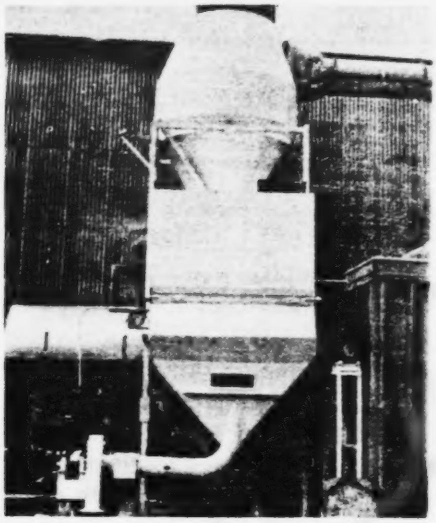
It is the belief of Ecology Industries, Inc. engineers that a properly installed system could easily be arranged to blow the shredded materials directly into an enclosed hauling vehicle or incinerator, or deposit the materials on a conveying belt or other mechanism, or could be used in conjunction with some other method of final processing or disposal.

Mixer:

Mixers may be simple, revolving drums, equipped with baffles and closely resembling concrete mixers. They may be either closed or open horizontal troughs, in which spiral flight blades fastened to a horizontal shaft revolve. In general, this equipment is similar to blenders, which have already been described. General use of this



Unsorted, bagged refuse is dropped in hopper (right foreground), conveyed pneumatically through duct to attrition mill below grade. Comminuted refuse is conveyed pneumatically through vertical duct to air separator. Material drops into bin (below air separator), whence it may be fed by conveyor to a packer truck, compactor or incinerator.



Comminuted refuse enters separator from horizontal duct (top right) and drops into bin. Special, variable speed conveyor moves material forward where it drops into fan pick-up chute. Fan (left foreground) delivers material to Incinerator for suspension burning. Temperature and smoke indicators and temperature controllers on panel (left rear). F.I.A. and F.M. approved gas control package below panel.

FIGURE IV-7

equipment is common in food and chemical processing industries where uniformity of mixtures is important. These units can handle a wide variety of materials, both wet and dry, such as granules, powders or slurries.

Packer, Roll-off:

S. Vincen Bowles, Inc. makes a packer which is similar to a stationary packer but the packer mechanism and the packer container are combined on a skid mount which is of the roll-off type. The skid is equipped with heavy rollers which permit it to be rolled onto or off of a heavy-duty tiltframe hoist. When fully loaded with compacted wastes, the roll-off packer is taken to a disposal point and there the packer blade pushes the load out through a rear tailgate. The empty container and packing mechanism is then returned to its usual location for reuse. The roll-off packer is produced in 25 and 30 cubic yard models. The overall lengths of the two sizes are 20 feet and 24 feet respectively.

Packer, Stationary:

The stationary compactor is widely used by industry, commerce and institutions. The stationary packer, with its large-capacity container, provides temporary outside storage facilities and does not take up costly enclosed space. Basically, this packer, sometimes called a fixed compactor, is comprised of two connected components - a stationary packing mechanism which remains in one location, and a detachable receiving container into which the wastes are compacted and periodically removed for emptying. The packer component consists of a receiving hopper for refuse delivered by chute, conveyor, cart or hand, and the hydraulic ram assembly used to compact the waste into the container. The closed container is attached to the packer so that the compaction blade can enter it through an opening in one end of the container. The opposite end has tailgate-type doors. The arrangement of packer components, some mechanical details and methods of hopper loading may differ between products of various manufacturers but the operating principles are quite similar.

Operation of the packer can be actuated manually or automatically controlled. Cycling controls provide a delay period so that loose materials will be compressed into the container when the packer hopper has a predetermined level of waste accumulated in it. When the compacted capacity of the container has been reached, it can be detached from the packer and removed by a truck equipped with a tiltframe hoist, and emptied by dumping through its rear tailgate-type doors at some disposal or processing point.

A wide range of sizes is available in the commercial series of stationary packers. Units with receiving hoppers of one to about eight cubic yards are marketed. The smaller sizes naturally accommodate smaller sized containers than do the largest models. Those packers having hopper capacities of about three cubic yards and upward are dock-loading types. These require the use of tilt carts and certain manufacturers incorporate their own hoisting and dumping platform for use with this type of cart. Prices of the stationary packers range from about $4,500 for the smallest packer to about $18,000 for larger sizes.

Several manufacturers produce small stationary packers suitable for apartment buildings and installations having relatively small quantities of wastes for disposal. The operating principles of these packers are essentially the same as the larger versions used in commerce and industry. In most installations, the charge box, or hopper, of the packer will be chute-fed and cycling operations are automated through the use of sonic controls. These small packer mechanisms occupy only about 15 square feet, exclusive of the containers which are used to receive the compacted wastes. The containers up to three cubic yard capacities are castered and can be moved manually if space does not permit pickup by a mobile packer. The manufacturers generally claim about four to one compaction ratio for the equipment. Prices of these small packers, exclusive of containers, will range from about $3,500 to $4,000.

Pulley, Magnetic:

These pulleys are used with belt conveyors and can be substituted for the usual pulley which would be installed at the discharge end of the conveyor. Special coil windings built into the pulley are supplied with electrical current and become electromagnets. As materials on the conveyor belt pass over the energized pulley, the ferrous materials will be held onto the belt by the magnets while the non-ferrous materials will fall off over the end of the belt. The magnetic materials will continue on the belt until the belt leaves the underside of the pulley. A divider, erected under the pulley, prevents the non-magnetic materials from mixing with the accumulated ferrous materials. These pulleys are used for the removal of unwanted tramp metal from materials being processed.

Pulper:

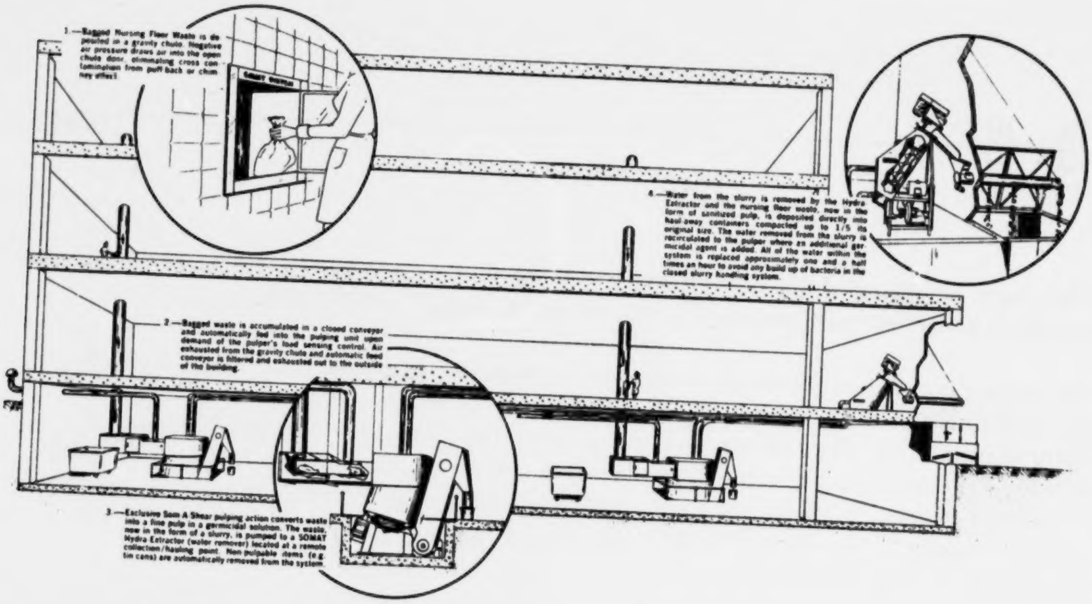
There are several solid waste processing systems on the market and in operation which utilize pulpers as the principal means of reduction. Generally, the pulpers are composed of a pulping bowl with a pulping impeller and waste-sizing ring in the bottom. Accessory equipment includes a junk or trash ejector and a dewatering press. The pulper and junk extractor are mounted directly adjacent to each other but the dewatering press can be located at some distance from the pulper and is connected by piping. It is possible to utilize multiple pulping stations and one dewatering press and in general, units can be located in the most convenient places since the slurry goes to the press and water is returned to the pulper by pipelines. These principles are illustrated in the accompanying photographs of a typical Somat system as manufactured by the Somat Corporation. Wastes can be introduced into the pulper by chute in floor models or manually fed in pit models. Capacities vary from about 400 to 4,000 pounds per hour.

In general, where only food wastes, paper and light institutional wastes are being processed, the equipment is reported to perform well. During the development stages of pulpers, considerable difficulty has been encountered in satisfactorily handling plastics, especially sheets, tubing and PVC containers, and occasional heavier materials such as commonly found in unselected hospital wastes.

(Black Clawson Company)

Black Clawson Company has recently introduced a system utilizing pulping as its operating principle. This organization has been manufacturing machinery for the pulp and paper industry for many years. This experience with heavy duty pulpers has given their waste reduction system some desirable features which appear to have improved the ability of a waste pulper to handle heavier and more dense materials. The manufacturer claims that tests already made indicate the hydrapulper can handle the full range of plastic items and unselected hospital wastes.

An important element in the satisfactory performance of this equipment is attributed by the manufacturer to the type of rotor and extractor bed plate used in the pulper. It is of a design which has been modified from the heavy duty equipment which can withstand continuous operation in the paper industry. Limited experience indicates that this pulper can satisfactorily handle the heavier, denser materials found in general solid wastes. The statement has been made by the manufacturer that the



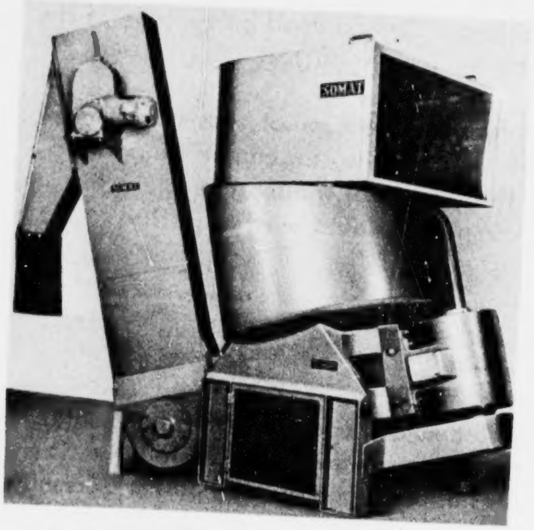
1.—Bagged Nursing Floor Waste is deposited in a gravity chute. Negative air pressure draws air into the open chute door, eliminating cross contamination from puff back or chimney effect.

2.—Bagged waste is accumulated in a closed conveyor and automatically fed into the pulping unit upon demand of the pulper's load sensing control. Air exhausted from the gravity chute and automatic feed conveyor is filtered and exhausted out to the outside of the building.

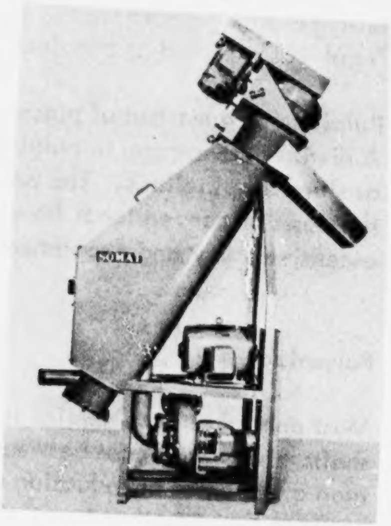
3.—Exclusive Som A Shear pulping action converts waste into a fine pulp in a germicidal solution. The waste, now in the form of a slurry, is pumped to a SOMAT Hydra Extractor (water remover) located at a remote collection/hauling point. Non pulpable items (e.g. tin cans) are automatically removed from the system.

4.—Water from the slurry is removed by the Hydra Extractor and the nursing floor waste, now in the form of sanitized pulp, is deposited directly into haul-away containers compacted up to 1/5 its original size. The water removed from the slurry is recirculated to the pulper where an additional germicidal agent is added. All of the water within the system is replaced approximately one and a half times an hour to avoid any build up of bacteria in the closed slurry handling system.

a. A Schematic Diagram Showing Multiple Somat Pulping Stations Connected with a Remote Dewatering Press



b. Somat Pulper with Automatic Junk Extractor



c. Hydra-Extractor or Dewatering Press

SOMAT SYSTEM - SOMAT CORPORATION

FIGURE IV-8

pilot plant has successfully pulped, among other things, small animals; garden trimmings, including branches and leaves; wire-bound crates and 2" x 4" lumber.

This system uses a junk remover to extract large particles of metal, glass and other unpulpable materials. These are deposited in containers for separate disposal. The slurry is piped from the hydrapulper to a dewatering press and the resulting residue or sludge is deposited as very moist, shredded material in containers for later disposal. It could be thoroughly dried to save transported weight or disposed of moist in a sanitary landfill, according to current practices. The arrangement of the components shows in the accompanying photograph.

The pilot plant was observed in operation at Middletown, Ohio. A large pile of freshly collected municipal garbage and refuse was available for testing purposes. A smaller load of hospital wastes, in plastic bags, was also on hand. The various materials were fed into the pulper bowl, using a portable belt conveyor. Observations indicate that both general types of wastes were adequately pulped. Only a small percentage of the input was rejected as unpulpable and removed by the junk extractor.

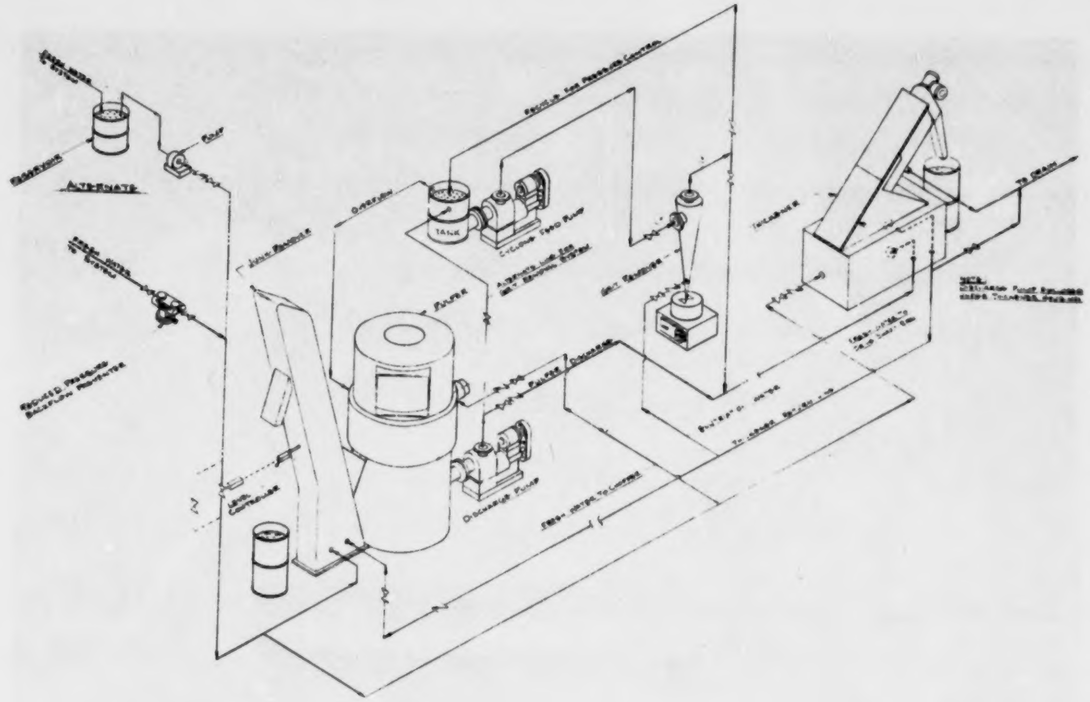
Pulping, as a method of processing solid wastes for ultimate disposal, has much merit. A distinct advantage to pulping is the ease with which the wastes can be transported as slurry in pipelines. The possible savings by this method of transport as against the costs of conventional handling in building complexes would seem to justify extensive study and experim[illegible]

Pulverizer:

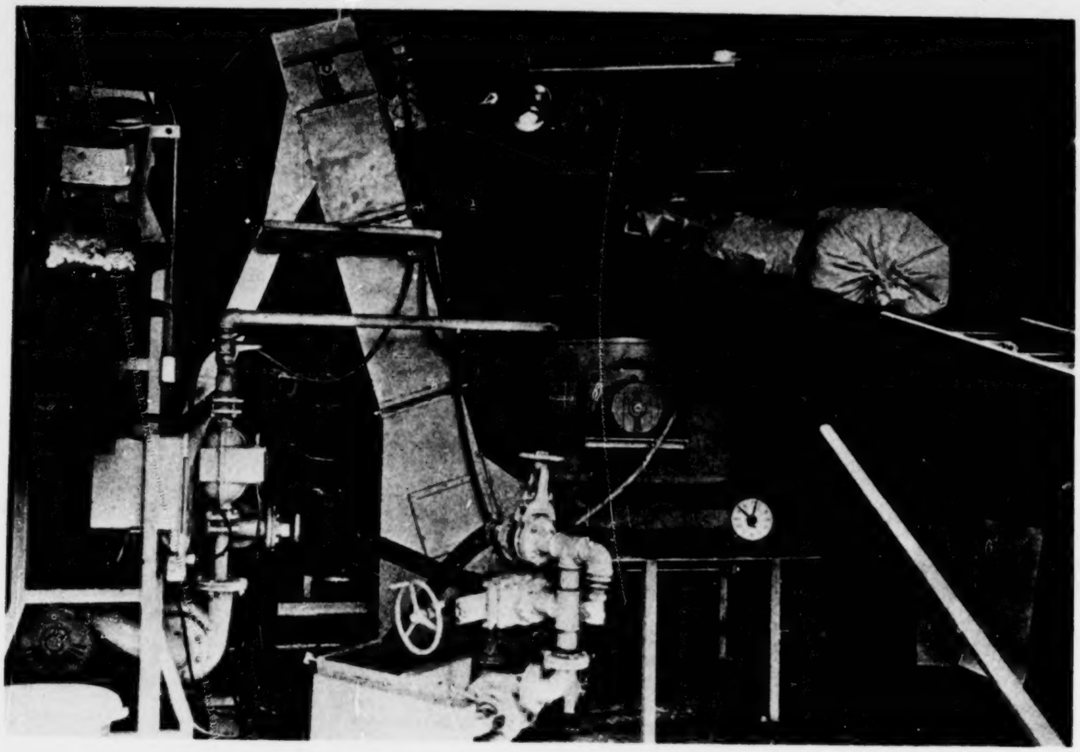
Most pulverizers are similar to hammermills or crushers and operate with a horizontal shaft. The clearances between hammers and casings are somewhat less with pulverizers than other types of reduction mills. Final screens or discharge grids in pulverizers may be finer than in other types of similar equipment.

("Tollemache" - The Heil Company)

The Tollemache refuse pulverizer system is manufactured and sold by The Heil Company. The basic machine is called a pulverizer and is capable of reducing municipal waste to particle sizes which can be readily handled by conveyors and packers. The


ALTERNATE
PUMP
FRESH WATER TO SYSTEM
REDUCED PRESSURE BACKFLOW PREVENTER
JUNK REMOVER
OVERFLOW
TANK
CYCLONE FEED PUMP
RECYCLE FOR PRESSURE CONTROL
PULPER
DISCHARGE
DISCHARGE PUMP
LEVEL CONTROLLER
GRIT REMOVER
THICKENER
TO DRAIN
NOTE:
FRESH WATER TO CYCLONE

Schematic Diagram of Black-Clawson Hospital Waste Disposal System



Black Clawson Pulping System

The Hospital Waste Disposal System Pilot Plant at the Shartle/Pandia Division of Black Clawson Company employs a hydrapulper, shown in the center of the picture, below the conveyor. Note inside of bowl, shown in mirror above it. The dewatering press, with its end-product "sludge" chute, is on the extreme left. The junk remover is between the pulper and the press.

FIGURE IV-10

Tollemache pulverizer is different in that it is a vertical mill. The hammers are arranged in three groups of four horizontal rings. The diameters of each succeeding group of rings is larger than the one above it - the smallest at the top, with the largest at the bottom.

The top of the pulverizer is a conically shaped, open hopper into which refuse is fed by conveyor. The cone merges with the cylindrical casing of the lower portion of the pulverizer. At the bottom of the conical section is an upward sloping chute through which non-reducible objects are thrown for rejection. The rejects are hit by the rapidly revolving hammers and literally thrown up the chute like a ball in a roulette wheel. Materials moving downward are reduced in size in a series of stages. No grates are provided since the end product is thrown out of the pulverizer much as a ballistic separator might do. The ground material is flung through an opening in the casing, onto a belt conveyor.

Developed for the heavy duty operation required to handle 15 tons of municipal waste per hour, this pulverizer is massive. No exact dimensions are available but the mill, exclusive of any conveyors, would occupy an area about 10' x 12' and would be about 15' high. The manufacturer claims that a waste reduction operation, based upon the use of this pulverizer, can be handled by a work force of two or three men.

Pulverizer, Paper:

This is a special purpose pulverizer which, it is claimed, will pulverize all types of paper, including IBM cards, photographs, medical and personal records and even offset plates and glass slides. The end product appears similar to coarse cotton. The complete system includes a cyclone separator, dust collector and a small compactor. The actual reduction device is a swing-hammer impact mill with a built-in pregrinding shredder. Models with capacities ranging from 300 to 10,000 pounds per hour are available.

Separator, Cyclone:

Probably the most readily recognized and perhaps the most commonly used separator is the cyclonic type. The conical bottom section and cylindrical top with ducts attached is a familiar sight in all industrial complexes. Used to remove solids from airstreams in industry, they operate on the principle of inertial separation. In the cyclone, mixtures of air and solid particles are introduced at the top. They are forced to spiral downward by pressure or suction. The inertial spin imparted to the particles forces them to the inner walls of the cyclone. The downward motion of the air drives the dust or particles to the bottom of the cone where its inertial energy carries the solids through an outlet. The cleaned air moves radially inward from the cyclone flow and it passes upward through an outlet. Separators operating on the cyclone principle are used to collect dust or undesirable particles and also to separate wanted solids, such as shredded materials, out of the airstream for further processing or disposal. The outlet air can be recirculated within a closed system or discharged to the atmosphere.

Separator, Magnetic:

These electromagnetic devices are made in several forms of bars, grates, grids and plates. They can be built into hoppers, chutes or conveying systems. They have many applications but their primary function is the removal of unwanted bits, pieces and particles of metal. Their magnetic capacities and capabilities are almost infinite and they can be provided to meet very unusual conditions.

Shredder:

Shredders are mills which are frequently used to reduce non-friable materials and are quite similar in principle to hammermills, grinders and crushers, although the shape of hammers or knives may be different from some other mills. Hammer shapes may be of the heavy "slugger" style or of the "hog" style. Others may be variations of ring hammers, with star shapes or roughly serrated edges.

Shredders are of two main types. The down-running shredder has material fed to it on the down-swing of the hammers. The over-running type receives material at the top of the mill and on the up-swing of the hammers. Over-running, sometimes called up-running, shredders or crushers are used with less friable materials, when a longer cycle in the mill is desired. Generally speaking, the size of grate openings and the arrangement and pattern of breaker plates will regulate the sizes of the finished products.

The wide variations in the composition of general or municipal wastes make two-stage reduction sometimes desirable. This is especially true if composting is to be the ultimate method of disposal. Regardless of ultimate disposition of shredded wastes, serious consideration should be given to the use of a primary and secondary shredder. This would result in a more uniform end product but would also provide some backup equipment for use under emergency conditions and for short periods of operation. While not as fully safe as duplicate equipment, some measure of assurance of a continuing process would be obtained.

Manufacturers' catalogs give little that is specific about the capacities of shredders. This is understandable when the wide variety of uses to which the equipment might be put is considered. However, one manufacturer alone lists about thirty sizes each for down and over-running shredders. Weights of the equipment run from 7,500 to 170,000 pounds in a wide range of capacities to suit almost any requirement.

Sieve, Dewatering:

These sieves have no moving parts. They consist of a steeply sloped screen held in a frame, with a feed or headbox at the top. Liquids or slurries to be strained are fed into the headbox, from which they flow over a weir and down the face of the sieve. The sieve is built of stainless steel and has transverse bars with slot spacing available from .010 inches to .100. Five standard widths from 18" to 72" and heights from 57" to 84" are available.

Sterilizer, Sludge:

This process usually consists of a combination of equipment components in a designed system for neutralization of contaminated industrial wastes and sewage sludge.

("Farrer System" - Dorr Oliver, Inc.)

A thermal treatment process known as the Farrer System is now being marketed by Dorr-Oliver, Incorporated. This process involves heat treatment of sludges in a range of 360° to 380°F for the desired period of reaction. By utilization of heat exchange principles, incoming sludge is heated to approximately 300°F by controlling outgoing treated sludge temperature at 85°F. A booster raises the preheated sludge to the desired temperature by means of heat from the main boiler. The heated sludge flows through a specially designed reactor at a controlled rate to insure desired retention time for full sludge conditioning. Following heat treatment, the sludge moves to a continuous flow decanting tank for separation. The separated sludge is then dewatered with a final moisture content of 50% to 60%.

The manufacturer further states there is no steam injection and no vapor discharge in this process. Dry sludge cake is sterile, odor-free, and bulk is reduced up to 10% of original volume. Operation is fully automatic. Precise heat control can be maintained regardless of surge loadings. Minimal operator attention is required. Continual improvements have produced a system widely accepted in Europe.

CHAP. V FINAL PROCESSING AND DISPOSAL METHODS

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Singularly, the most emphasized need and least developed function or activity in solid waste management is that of disposal. Conversely, however, the greatest investment and advances in equipment for solid waste systems occur in handling, storage and processing functions preceding disposal. Development of satisfactory disposal processes, free of pollution effects on the environment, has been lagging and processes are still being researched.

Disposal is considered herein as the final treatment or combination of treatments in the conversion of wastes to innocuous materials or useable by-products. By and large, known disposal methods are limited to relatively few conversion processes, some involving conversion by normal decomposition of materials and several processes which involve accelerated conversion.

Conversion of waste materials may be accelerated by destructive disposal processes, such as controlled incineration and supervised or unsupervised open burning. These processes produce high volume reduction of solids with the end product of these processes being a mixed residue including ash and non-combustible materials of high density, as well as gaseous air pollutants. Conversion may also be accomplished by natural composting or accelerated by means of various mechanized systems. Products of these mechanized composting systems are a sterile organic soil and gaseous air pollutants. The composting process in itself does not greatly reduce the volume of waste materials. However, substantial reduction in the end product may be accomplished in conjunction with those reclamation activities normal with composting processes and where high ratios of salvageable materials are present. Grinding of food wastes for discharge to sewers with ultimate processing at treatment plants and final deposit of sludge at sanitary landfills or use as soil conditioner is popularly accepted in many areas as the best method of disposal of garbage. In addition, other terminal processes such as wet air oxidation, which may produce a sterile slurry or ash cake, and pyrolysis, a destructive distillation process producing sterile charred solids, are among the numerous newer conversion processes being explored for development.

Salvage of selected waste materials in the past has had great significance and currently this reclamation concept is regaining popularity, although economics are not always favorable. Among the materials of greater significance for salvage are paper, rags, ferrous and non-ferrous metals, glass and rubber. Other salvage processes such as rendering of animal carcasses and fats for production of fertilizer, glue, soaps, etc., as well as salvage of food wastes for swine feeding, still prevails in many areas of the country. Both methods generally require segregation of the wastes at the source of generation and often require refrigerated storage. Excessive handling costs in nearly all reclamation processes are the overriding factors in the economic feasibility of disposal by various reclamation processes.

Disposal by sanitary landfill, open dumping and dumping at sea are the only processes where conversion is not accelerated by man and where normal decomposition of the organic material occurs. However, dumping of solid wastes in the sea or inland bodies of water has in recent years been outlawed for all practical purposes. In both sanitary landfill and open dumping methods, substantial settlement of the material occurs during decomposition, together with production of gaseous emissions. Open dumping, the most common practice used in the disposal of solid wastes, has in recent years received strong criticism from governmental agencies and the general public. The only currently acceptable method of disposal by landfill is management of sanitary landfills adhering to accepted standards of construction and daily maintenance. Continuing studies on sanitary landfills are being conducted in efforts to produce land on completion of such operations that will have a wider range of use than current experience indicates is permissible.

The above broadly indicates the total range of disposal methods currently available. For purposes of this report, we are primarily concerned with selection of ultimate disposal methods that are suitable for the special categories of wastes commonly generated in hospitals, office buildings and detention facilities. From the foregoing studies covered in Volume I and II, quantities, types and characteristics of waste produced at each of these types of facilities, together with an evaluation of present disposal methods employed, were explored in some depth. Based upon these studies, the following criteria in the selection of disposal methods for each building type was established.

Hospital Wastes: The evaluation of hospital solid waste systems indicated that maintaining separate collection channels for contaminated and non-contaminated wastes cannot be practically or economically enforced in the conventional hospital facility. Segregation of waste materials throughout the system must rely heavily on the human element of judgment in the classification and distinction of these types of materials. Generally, an intermix of materials occurs due to difficulty of identification and the inability of the workers to make a distinction. Even intermixing of disposables and reusables is commonplace. As a result of these observations, this study has adopted the theory that all wastes coming off the hospital floor can be classified as contaminated materials. It must be pointed out that such classification of hospital wastes is not currently accepted by all authorities. Composition of these wastes include many salvageable materials that could prove harmful upon reclamation and reuse. Based upon these conditions, it was concluded that on-site disposal should be preferred or on-site processing of these materials should be accomplished to produce a sterile homogeneous material suitable for safe off-site transport and disposal.

Office Building Wastes: Composition of wastes generated in the office buildings studied were neither hazardous nor objectionable when related to handling or disposal. Largely consisting of paper with an intermix of small quantities of food wastes and non-combustibles, these materials are generated in relatively low volumes. No restrictions appear necessary on the disposal of materials of this type. However, in interests of security of confidential information, as well as general building safety, consideration should be given to first stage processing of this material such as shredding and/or compaction or baling preceding ultimate disposal. Selection of disposal methods will likely be limited to incineration and landfill or salvage where quantities of materials warrant.

Detention Facilities: Disposable wastes generated in detention facilities were previously identified as rubbish and food wastes not unlike general municipal wastes. It was found in earlier investigations that detention facility waste systems are largely operated by inmates and equipment in this operation is intentionally limited. It was concluded that on-site processing or disposal involving mechanical equipment subject to the operational abuse by inmates should be avoided and that off-site disposal would be preferred. Nature of the waste materials present no greater hazards in disposal than in normal municipal wastes and may satisfactorily be disposed of by conventional methods such as landfilling or incineration.

The research and investigation of disposal methods has been closely interrelated with the investigation of processing methods as reviewed in the preceding chapter. The purpose of this section of the report is to review the various disposal processes and the combinations of equipment components for processing solid wastes as currently being researched by manufacturers, in efforts to develop, select and evaluate satisfactory disposal systems for the various types of buildings under study.

Organization of material in narrative review presented herein is limited to the discussion of disposal processes rather than review of individual equipment components such as presented in the preceding chapters on handling, storage and processing. However, specialized equipment components utilized in these various processes are discussed as appear warranted within the review of each disposal process. These equipment components are further identified by classification, definition and manufacturer in Appendices "G" and "H".

SANITARY LANDFILL

Sanitary landfills designed for local conditions, on suitable sites and operated in accordance with accepted standards have proven to be one of the most satisfactory methods of waste disposal currently available. Where suitable sites are available within reasonable haul distances from sources of waste generation or collection areas, it is likely the most economical method of disposal.

Considering the nature and characteristics of the types of wastes generated in office buildings and detention facilities, disposal by sanitary landfill would be an acceptable method. It would also be an acceptable method of disposal for hospital wastes providing these materials were properly conditioned for off-site transport and disposal prior to dispatch from the hospital plant. Minimum conditioning immediately following collection should include grinding, shredding or pulping and dewatering, or other processes to reduce the mixed unselected wastes generated in hospitals to a homogeneous, unidentifiable material. In addition, this material should be subjected to a sterilization process producing an innocuous end-product that may be safely transported off-site for handling at nearly any type of landfill operation. These conditioning processes would provide multiple benefits. Reduction of the material to a homogeneous state would not only preclude the possibility of off-site salvage and reuse of contaminated articles but also prevent the equally important possibility of on-site salvage before waste materials are dispatched to the disposal site. A controlled sterilization process would further assure against transmission of disease and environmental pollution both during off-site transport and at the disposal site.

To further qualify the above limitations recommended for disposal of hospital wastes in sanitary landfills, the following general discussion on factors of off-site disposal as presented in Volume I is repeated herein.

No conclusive research directly related to off-site disposal of hospital wastes and its effect on the community has been performed. Principal concerns relate to the possible survival of harmful bacteria and disease transmission by direct human contact with contaminated materials or through other biological vectors, as well as transmission through air and water pollution. Off-site disposal conventionally involves a method of highway transport, direct or via transfer stations to landfills or central incineration plants. The community environment may be exposed to hospital waste contaminants throughout the course of travel with greatest potential exposure occurring at the disposal site where direct contact by refuse workers and scavengers may occur or where water pollution via run-off or leaching may ultimately affect the populace.

General observation in Los Angeles County and other areas inspected indicate that other than identified pathologic wastes which represent a small percentage of total wastes, the majority of mixed waste materials are being transported to area landfills. It is also likely that the majority of hospitals, especially those of less than 500 beds, are serviced by private refuse contractors or public collection agencies. Largely these waste materials are not identifiable as hospital wastes as they are received at landfills. Collectors servicing private institutions as well as some of the public facilities provide routine servicing, and therefore the majority of hospital wastes are mixed with commercial and/or residential wastes prior to delivery to disposal sites and could not feasibly receive special handling.

Based on the above factors and limited knowledge in this field as to immediate and long-range effects, elimination of these potential hazards to the community environment through on-site disposal or such processing as discussed would likely be recognized as the preferred method from the viewpoint of public interest. Regardless of the system selected, assurance of its proper operation to minimize environmental contamination, both within the plant and the community, is paramount and is emphasized should off-site disposal be the only feasible alternative available to the community.

It is acknowledged that by definition, sanitary landfill includes the controlled disposal of wastes and special handling of identifiable hazardous wastes. In communities where such methods are employed and where separate collections of hospital wastes are feasible, off-site disposal in this manner may be acceptable. Potential hazards to the environment may be minimized in transport through tight containerization, and at sanitary landfill sites through special handling procedures, such as immediate compaction and cover, as well as tight security and proper selection of site.

RECLAMATION

Reclamation, defined as the act or process of reclaiming, for purposes of this study is all inclusive of those activities connected with salvage of useable materials, products, or by-products in the disposal of solid wastes. Major reclamation activities considered herein include the direct salvage of useable mixed materials such as garbage and food wastes for swine feeding, remnants of animal carcasses and fats for rendering, as well as the salvage of specific products, such as paper, metals, glass, etc. that may be recycled in the production of new materials.

Recovery of by-products that may be achieved during conversion or disposal processes are also considered reclamation activities and include such processes as waste heat recovery from incineration, compost from composting, charcoal from pyrolysis, etc.

For purposes of this study, evaluation of the suitability of the disposal process, rather than the potential recovery of by-products, is the chief concern. Those disposal processes capable of producing by-products will be discussed in later sections of this chapter as may be warranted. This section will be confined to the direct salvage of useable materials and products as noted above and as related to the various types of buildings and respective wastes under consideration.

Swine Feeding:

Collection of garbage by commercial haulers or piggeries for hog feeding remains as an accepted method of disposal in many areas of the country. However, this method now under the strict control of health agencies is permissible only when the waste material is conditioned by accepted cooking procedures. These enforced procedures, together with prevailing zoning, plant design and licensing requirements in most areas are the basic controls which have been developed to permit this industry practice to continue and to eliminate transmission of certain diseases via hog feeding. Since the mid-fifties, these types of controls have been adopted in all states, with the responsibility of enforcement on local health agency officials. The regulations, primarily in the interest of public health, also encourage compliance of the commercial piggery operator, which in effect provide insurance against loss due to herd infection and required destruction of the infected animals.

Properly conducted in accordance with current standards of operation, the age-old practice of hog feeding as a method of disposal, fulfills the popular concept of recycling of waste materials in the interests of conservation.

Relating this method of disposal to the food wastes generated in detention facilities and office buildings, it would appear as an acceptable method when these materials are generated in sufficient quantities whereby collection is economically feasible. In the case of food preparation wastes generated in hospitals, it would also be acceptable, providing these materials can be properly segregated. Approval of this method for disposal of food wastes generated in hospitals should be at the discretion of the local health officer and indicated public acceptance in the community involved.

Rendering:

Rendering animal and fish carcasses is still a significant method of disposal, as well as a recognized process in the production of fertilizers, glues, soap, oils, etc. It is a common and accepted method of disposal in the larger communities.

Rendering, as considered in this study, would be an acceptable method of disposal for remnants of animal and fish carcasses resulting from food processing at detention facilities or office building cafeterias. It would also be an acceptable method of disposal for similar wastes produced in hospitals if segregated from contaminated wastes until collected. In all such cases, refrigerated storage must be provided for this type of material due to normally infrequent collections.

This method cannot be recommended for the disposal of small animal carcasses resulting from laboratory and research activities in hospitals. Should this method be considered, it should be subject to the approval of health agencies. The decision should be dependent on the type of research conducted on specific animals, the hazard these carcasses might present in handling and off-site movement or in the residues produced in rendering.

Product Salvage:

Several factors must be evaluated when considering salvage of specific products from wastes generated in hospitals, detention facilities and office buildings. Principal materials generated at these types of buildings that may have potential salvage value include paper, metals and glass. By and large these materials are intermixed during collection. Relatively small quantities of the individual waste materials are generated, hence separate collection and segregation of the materials cannot be economically justified as an in-plant activity.

Due to the nature of wastes generated in hospitals, as previously defined, direct salvage of products should not be considered either at in-plant or at off-site locations. Recovery of materials with salvage could be considered only after the intermixed wastes were subjected to a complete sterilization process. It can be readily assumed that it would not be economically feasible to sterilize these materials for the single purpose of salvage. However, if sterilization was justified for other purposes, salvage of select materials might prove feasible.

The nature of wastes generated at detention facilities are estimated to have a relatively low proportion of salvageable products as opposed to office building wastes where a high proportion of salvageable paper may be found. However, due to the relatively low waste production (by weight) found in office buildings, coupled with the prevailing requirement for daily service in removal of these wastes by private refuse contractors, significant benefits from potential salvage of these materials cannot be expected by the building owner or tenant. The private contractor in most cases is primarily providing a reliable refuse removal service to the customer. Salvage benefits that may be derived from these mixed wastes should rightfully accrue to the contractor or ultimate processor, especially when considering price variations that occur in the salvage market.

As a result of quantity surveys on wastes generated in office buildings as reported in Volume II of this study, it was found that average daily production was slightly less than 2.5 pounds per thousand square feet. Typical of buildings investigated was one with an area of 1,000,000 square feet producing a total of about 2,000 pounds of wastes per day. Considering the salvage value of about $20-$25 per ton for baled paper as prevailed in 1969, substantially greater quantities of waste paper would necessarily be generated daily at any building to warrant separate collection and central processing exclusively for salvage.

In summary, the nature of waste materials produced in detention facilities and office buildings present little hazard in handling and would be suitable for disposal by partial salvage if economically feasible to commercial salvage firms. It is unlikely that in-plant salvage would prove feasible except in extremely large buildings or complexes. In the case of hospital wastes, salvage of products cannot be recommended and in any case should not be considered except after positive sterilization by some proven method.

COMPOSTING

Mechanized systems of composting presently in development stages rely on the principle of accelerated aerobic decomposition of organic materials. This method of disposal under controlled conditions is suitable for wastes of high organic content and produces a sterile soil with potential value. However, developing markets for the end-product has been one of the principal obstacles in popular use and acceptance of these systems, for without a sufficient monetary return from the sale of compost, the economic feasibility of this method of disposal appears at best, marginal. Other economic returns derived from this process are income produced from salvage operations normally associated with composting plants. Products salvaged include paper, metals, glass, rags, rubber, etc. dependent upon current demands of the salvage market.

Considering composting as the final disposal process for wastes generated in hospitals would be conditional. As in the case of other off-site disposal methods that may be considered, it is vital that certain of the waste materials such as disposable syringes, needles, instruments, etc. should be destructed and sterilization of all waste materials should be accomplished by some proven method prior to dispatch from the hospital plant.

The nature of wastes generated in detention facilities, although considered to be proportionately low in salvageable materials, would as domestic wastes be suitable for composting. Wastes generated in office buildings would have proportionately high salvage value in paper content and likely relatively little value for compost as such.

INCINERATION

Incineration, one of the most effective methods of reducing the bulky volume of solid wastes, produces a relatively innocuous residue that is reasonably safe and easy to handle. Ultimate disposal of this residue in a landfill requires but a fraction of the space necessary for burial of the raw wastes, hence, the useable life of any given landfill area may be prolonged.

That incineration is sometimes looked upon with disfavor is not necessarily the fault of the process or the equipment. Although faulty installations can often be traced to improper design, due to lack of knowledge on the part of the designer, improper selection of package units or components or even penuriousness in budgeting, the blame for poor performance often lies in the hands of those who are responsible for the operation of plants and equipment at management, supervisory and operating levels. The best designed and built plant, of any kind, will not perform satisfactorily if improperly operated. This applies to sewage or water treatment plants, or other mechanical equipment installations, as well as incinerators. It is strongly recommended that where installations of incinerators are made, they be manned by people who understand the operation of major equipment involving heat and power. For example, providing incinerator operation was carried out in conjunction with the operation of power or steam generating plants, it is likely the level of efficient and satisfactory performance would be improved, for the operating crews of these plants have the necessary training to understand incinerator operation. To assign the operation of incinerators to the least skilled and lowest paid personnel is inviting a level of operation which will not meet even the barest minimum of standards.

The discussion of incinerators herein will be limited to the types of equipment which are most applicable to the problems with which this report is concerned and will include the smaller capacity equipment, those usually identified as package and on-site incinerators, pathological incinerators and crematories. Consideration of the use of an incinerator for waste disposal should be preceded by a review of the Standards of the Incinerator Institute of America, to which the reader is referred. Included in these standards are the Institute's "Classification of Wastes and Incinerators" reproduced on the following page for the reader's convenience.

The selection of equipment will depend upon the conditions which must be met. To

CLASSIFICATION OF WASTES AND INCINERATORS

The basis for satisfactory incinerator operation is the proper analysis of the waste to be destroyed, and the selection of proper equipment to best destroy that particular waste.

As a guide, mixtures of waste most commonly encountered have been classified into types of waste, together with the B.T.U. values and moisture contents of the mixtures. A concentration of one specific waste in the mixture may change the B.T.U. value and/or the moisture content of the mixture. A concentration of more than 10% by weight of catalogues, magazines, or packaged paper will change the density of the mixture and affect burning rates.

Similarly, incinerators have been classified, by their capacities and by the type of wastes they are capable of incinerating.

CLASSIFICATION OF WASTES

Type 0 — Trash, a mixture of highly combustible waste such as paper, cardboard, cartons, wood boxes, and combustible floor sweepings, from commercial and industrial activities. The mixtures contain up to 10% by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags and plastic or rubber scraps.

This type of waste contains 10% moisture, 5% incombustible solids and has a heating value of 8500 B.T.U. per pound as fired.

Type 1 — Rubbish, a mixture of combustible waste such as paper, cardboard cartons, wood scrap, foliage and combustible floor sweepings, from domestic, commercial and industrial activities. The mixture contains up to 20% by weight of restaurant or cafeteria waste, but contains little or no treated papers, plastic or rubber wastes.

This type of waste contains 25% moisture, 10% incombustible solids and has a heating value of 6500 B.T.U. per pound as fired.

Type 2 — Refuse, consisting of an approximately even mixture of rubbish and garbage by weight.

This type of waste is common to apartment and residential occupancy, consisting of up to 50% moisture, 7% incombustible solids, and has a heating value of 4300 B.T.U. per pound as fired.

Type 3 — Garbage, consisting of animal and vegetable wastes from restaurants, cafeterias, hotels, hospitals, markets, and like installations.

This type of waste contains up to 70% moisture, up to 5% incombustible solids, and has a heating value of 2500 B.T.U. per pound as fired.

Type 4 — Human and animal remains, consisting of carcasses, organs and solid organic wastes from hospitals, laboratories, abattoirs, animal pounds, and similar sources, consisting of up to 85% moisture, 5% incombustible solids, and having a heating value of 1000 B.T.U. per pound as fired.

Type 5 — By-product waste, gaseous, liquid or semi-liquid, such as tar, paints, solvents, sludge, fumes, etc., from industrial operations. B.T.U. values must be determined by the individual materials to be destroyed.

Type 6 — Solid by-product waste, such as rubber, plastics, wood waste, etc., from industrial operations. B.T.U. values must be determined by the individual materials to be destroyed.

CLASSIFICATION OF INCINERATORS

Class I — Portable, packaged, completely assembled, direct fed incinerators, having not over 5 cu. ft. storage capacity, or 25 lbs. per hour burning rate, suitable for Type 2 Waste.

Class IA — Portable, packaged or job assembled, direct fed incinerators 5 cu. ft. to 15 cu. ft. primary chamber volume; or a burning rate of 25 lbs. per hour up to, but not including, 100 lbs. per hour of Type 0, Type 1, or Type 2 Waste; or a burning rate of 25 lbs. per hour up to, but not including, 75 lbs. per hour of Type 3 Waste.

Class II — Flue-fed, single chamber incinerators with more than 2 sq. ft. burning area, for Type 2 Waste. This type of incinerator is served by one vertical flue functioning both as a chute for charging waste and to carry the products of combustion to atmosphere. This type of incinerator has been installed in apartment houses or multiple dwellings. (See notes on page 2B.)

Class IIA — Chute-fed multiple chamber incinerators, for apartment buildings with more than 2 sq. ft. burning area, suitable for Type 1 or Type 2 Waste. (Not recommended for industrial installations.) This type of incinerator is served by a vertical chute for charging wastes from two or more floors above the incinerator and a separate flue for carrying the products of combustion to atmosphere.

Class III — Direct fed incinerators with a burning rate of 100 lbs. per hour and over, suitable for Type 0, Type 1 or Type 2 Waste.

Class IV — Direct fed incinerators with a burning rate of 75 lbs. per hour or over, suitable for Type 3 Waste.

Class V — Municipal incinerators suitable for Type 0, Type 1, Type 2, or Type 3 Wastes, or a combination of all four wastes, and are rated in tons per hour or tons per 24 hours.

Class VI — Crematory and pathological incinerators, suitable for Type 4 Waste.

Class VII — Incinerators designed for specific by-product wastes, Type 5 or Type 6.

Standards of the Incinerator Institute of America

FIGURE V-1

speculate or to deal with hypothetical quantities of wastes, their composition, rates of creation and many other factors would serve no useful purpose here. Suffice it to say that a complete survey of conditions must be made and from the data collected, the required criteria can be established. Further details on design criteria are discussed later in the section on "Incinerators for Hospitals".

Careful attention must be given to keep abreast of regulatory measures and codes. In certain areas of the country, these become more restrictive almost daily and what was acceptable last year may not do today. Consultation with responsible authorities must be had with some frequency before final selection of incinerating equipment and accessories is made. It may be added without reservation that incineration of relatively small quantities of mixed wastes in a manner whereby emissions will be at acceptable levels will be relatively expensive in initial costs and that budgets should be generous in the area of combustion accessories, air pollution control devices and controls. However, with proper maintenance and operation, operating costs can be held within reasonable economic limits.

Research and development on various newer principles of incineration are actively being pursued by many manufacturers; however, development is largely aimed at high capacity units for municipal incineration rather than the smaller units applicable to this study.

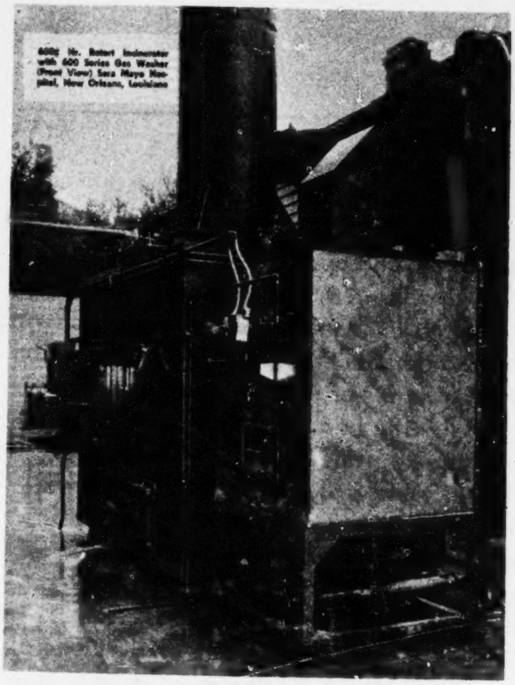
Typical of the conventional package incinerators marketed for on-site installation is the 600 pound per hour retort incinerator and the 50 pound per hour pathological incinerator as manufactured by Sargent NCV Division of Zurn Industries, Inc. These units as described below are shown in the accompanying photographs.

The R 600-1 incinerator is classified as a heavy duty destructor of the retort type capable of handling Class I or Class II wastes. The manufacturer claims it meets the standards of the Incinerator Institute of America for this type of equipment and complies with the requirements of Class III, Class IV, Class VI or Class VII incinerators. Advantages claimed for retort type over in-line incinerators include substantial space savings due to reduced length of the retort equipment and some increase in burning efficiency of this type of unit. The R 600-1 retort incinerator requires a space of about 13'-0 x 9'-0 with about 14 feet of vertical clearance. The unit is 7'-6" high without allowances for stack connections. The cost of this unit is about $7,000 f.o.b. plant excluding installation.

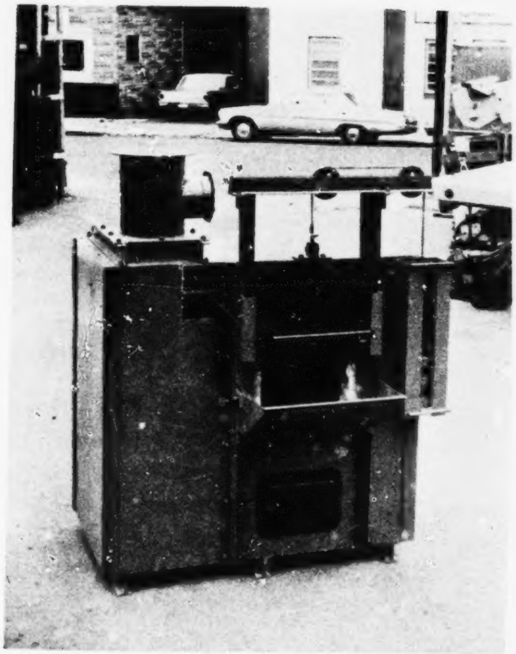
The gas scrubber unit (model 600) for this incinerator is of the wet impingement type and has a capacity of 6,480 pounds of gases per hour, at temperatures up to 2,000°F. This equipment requires 6 gallons of water per minute at 30 psi. Standard models include stainless steel inlet sections with alloy steel outer shell. However, complete stainless steel construction should be specified for acid or pathological wastes. Space requirements will vary slightly depending upon whether the scrubber is equipped with either a top or side inlet, but generally a space 8'-0" x 6'-0" with 13 feet of vertical clearance will accommodate either model. Approximate cost of the model 600 scrubber is $4,000. Other accessories such as a pyrometer and control panel are priced at $100 and $450 respectively.

Pathological-type incinerators capable of handling Type IV wastes are available in six models with capacities varying from 50 to 300 pounds per hour. They incorporate overlapping hot-hearth type incinerators. The model P-50 has a capacity of 50 pounds of Class IV wastes per hour. It has 5.6 square feet of hearth area in a 9.9 cubic foot combustion chamber. This unit requires a minimum space of 9'-0" x 4'-0" with vertical clearances of 7 feet. The model P-50 costs approximately $3,170 f.o.b. plant equipped with two gas burners but excluding installation.

If required, this incinerator may be equipped with a model 100 gas scrubber, pyrometer and control panel at an additional cost of about $2,350. This gas scrubber has a capacity of 1,080 pounds of gases per hour and requires one gallon of water per minute at 30 psi. If retention chambers are required for gas scrubbers, they are available at $350 per unit. Chain hoists for operating destructor charging doors cost about $250. No duct work costs are included in any of the prices given.


600# Hr. Retort Incinerator with 600 Series Gas Washer (Front View) Sara Mayo Hospital, New Orleans, Louisiana

Sargent Retort Incinerator



Sargent Pathological Incinerator
(50 Pound Per Hour Capacity)

FIGURE V-2

The above briefly describes the principles of application and operation of the smaller package incinerators as well as accessories that are available. Improvements in package incineration over the years has been largely confined to changes in design of components, such as shape of combustion chambers, kinds of refractory lining, methods of introducing and controlling combustion air, modifications of afterburner principles, and other air pollution control devices, stack design, methods of stoking and ash removal, automated controls, etc. In short, incineration is a highly complex process. Design of installations should not be left to catalog selection of equipment or for the evaluation of the layman. It should be stressed that qualified engineers experienced in incineration design should establish design criteria and prepare necessary designs, specifications and operating procedures for all types of incinerator installations. These engineering functions are further detailed in the following section on "Incinerators for Hospitals" as prepared by Elmer R. Kaiser for this study. It may be added that many of the general requirements and broad principles established are also applicable to on-site incineration for many types of buildings, as well as hospital installations.

INCINERATORS FOR HOSPITALS by Elmer R. Kaiser, P.E.*

Destruction of hospital wastes by incineration is an established, sanitary and economical practice. Improvements in incinerator design and the use of modern high efficiency washers for the combustion gases have made incinerators more acceptable. On-site incineration reduces hazards and contamination in the handling and disposal of hospital wastes, particularly by waste handlers who are unfamiliar with the dangers associated with such wastes.

The purpose of this presentation is to provide guidance to hospital administrators, architects, engineers and others in the considerations for an incinerator facility. For a new hospital, the architect will find it particularly advisable to regard waste management as an important function and to allocate ample space for it. In the past, the incinerator was too often relegated to a cramped area in the basement with awkward arrangements for the transport of refuse and burned out residue.

Incinerator plant design by professional engineers includes consideration of the refuse quantities and types, material handling of refuse and residue, incinerator selection and room layout, air pollution control, safety, utilities, and cost. Only rudiments of the hospital incinerators will be discussed in this article.

A survey of refuse types and weights is advisable for existing hospitals before deciding on the size of incinerator to be installed. The survey should be conducted for a week or more, with all refuse weighed and recorded by days. The daily number of bed patients should also be noted for comparison. If feasible, the weight of metal, glass and other non-combustibles should be determined.

In general, incinerable refuse consists of free moisture, dry combustible matter, and inerts. Moisture is that fraction which evaporates by heat drying in air at not over 212 F. Moisture contents vary from about 8 per cent for paper to 85 per cent for food waste. Metal, glass and the mineral matter associated with most organics are deemed inert for incineration, although some oxidation of metals does occur in the fire.

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Calorific values of the dry, inert-free, combustibles also vary from 7,500 to 19,000 British thermal units (Btu) per pound, with an average of about 10,000 Btu per pound. Hospital waste of 10 per cent moisture and 5 per cent inerts, known as Type 0 waste, would thus have a calorific value as fired of 10,000 (1.00 - 0.10 - 0.05) = 8,500 Btu per pound. Type 1 waste has 25 per cent moisture and 10 per cent inerts, with a calorific value of 6,500 Btu per pound. Hospital waste ranges between Type 0 and Type 1. For design purposes, the more conservative selection is Type 0 waste.

Most hospital waste is now placed in plastic bags near the point of origin and is delivered to the incinerator area, rather than as loose rubbish.

Requirements for segregation are minimal; however, identifiable aerosol cans and containers of highly combustible liquids should be collected separately and delivered to the incinerator operator for special handling. The incinerator operator can dispose of such wastes with greater safety if he receives them separately.

Where waste is delivered to the incinerator room at any time of day or night, but burned only during the daytime shift, storage space must be provided in a separate room or on the charging platform of the incinerator.

Incinerator residue removal from the incinerator area and from the premises also requires planning. Covered ash cans or special transportable containers are available. By use of can hoists and rubber-tired carts, manual lifting and noise are reduced to a minimum. Good housekeeping is as feasible in the incinerator area as in any other hospital area.

Incinerators:

Incinerators, also named destructors, are engineered products available from nationally established manufacturers. They are multi-chambered, refractory lined, heat insulated and brick cased or steel cased. Auxiliary equipment for high combustion efficiency includes overfire air blowers and nozzles, gas burners, temperature sensors, and dampers. Air pollution regulations are met with gas washers or scrubbers, which remove the fly ash from the combustion products.

The purpose of the incinerator is to reduce the volume and weight of refuse by combustion. Moisture and hydrogen are converted to water vapor. Carbon is burned to carbon dioxide. Both water vapor and carbon dioxide are natural constituents of the atmosphere and support plant life. They are not air pollutants.

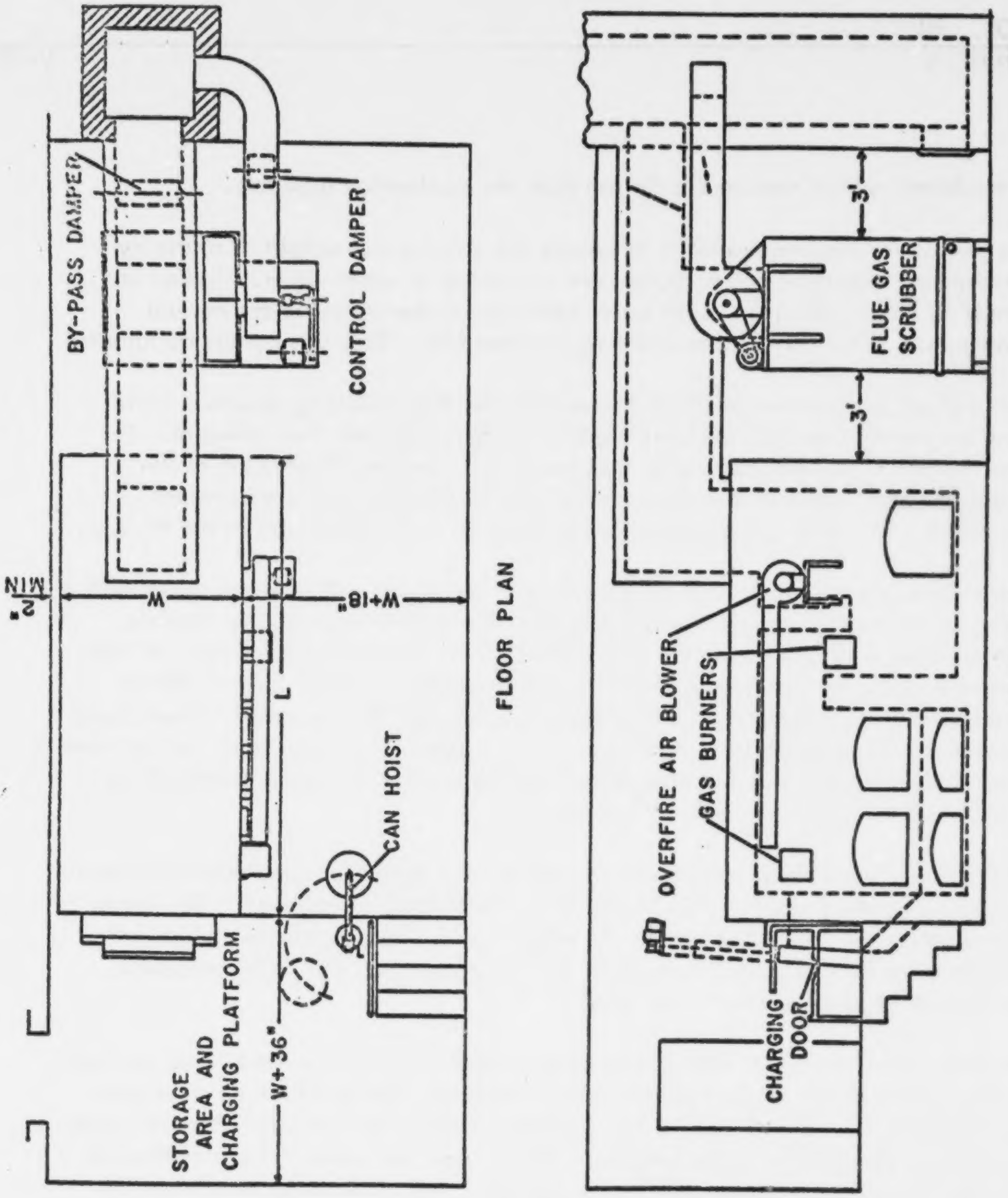
Bottle glass decrepitates to shards by heat shock, thus reducing volume. Metal cans are burned free of labels and organic linings, and lose their strength. The final weight of residue (ash, glass and metal) will be 5 to 10 per cent of the original refuse, depending mainly on the amount of metal and glass present in the refuse. The heat generated promotes sterility in the gases and in the residue.

Figure V-3 is a typical layout for guidance to architects. The design shows end firing of the incinerator, but side firing at either side is also equally feasible. While Figure V-3 also shows the incinerator, flue, scrubber and chimney in line, turns are also possible without sacrifice of performance. Thus, an incinerator installation is adaptable to building designs, provided that certain minimum floor areas and ceiling heights are provided. An independent air supply to the incinerator room is also necessary as the combustion process requires 10 to 15 pounds of air (133 to 200 cu ft) per pound of refuse burned.

Incinerator and scrubber manufacturers will furnish dimensions and discuss layouts. The charging platform shown in Figure V-3 is definitely advisable for the larger incinerators, but is not needed for the small units. Power operated stokers are advisable for incinerators burning over 2,000 lb per hour, but cast iron grates are commonly used on other destructors.

The size of incinerator is determined by the weight of refuse to be burned per hour. Typical refuse firing is once every 15 or 20 minutes, during which no more than one fourth to one third of the hourly capacity is charged manually. Bagged refuse is easier to charge than loose material. Air is admitted under the grates through air registers or louvers provided for the purpose. Air is also supplied above the grate through registers or louvers, as well as by the overfire air blower.

For complete combustion the operating temperatures in the primary and secondary


BY-PASS DAMPER
CONTROL DAMPER
2" MIN
W
W+18"
L
CAN HOIST
STORAGE AREA AND CHARGING PLATFORM
W+36"
FLOOR PLAN
FLUE GAS SCRUBBER
3'
3'
OVERFIRE AIR BLOWER
GAS BURNERS
CHARGING DOOR
ELEVATION

(A Typical Arrangement for Hospital Refuse Incinerator)

FIGURE V-3

combustion spaces should be in the range of 1,400 F to 1,800 F. Gas burners are provided for preheating the incinerator and for maintaining the temperatures.

Overfire air assists combustion of the refuse and flames by supplying air (oxygen) and promoting mixing (turbulence). Burning rates should not exceed 25,000 Btu an hr per cubic foot of combustion space in the chambers.

Incineration of hospital refuse will provide a reduction ranging up to 90% in weight and 95% in volume, with the density of the residue decreasing as the ratio of bulky inerts, such as tin cans, increases. There will be a considerable variation based on composition of the input.

Air Pollution Control:

Stringent requirements of Federal, state and local regulations directed toward the prevention of air pollution can be met with available incinerator flue-gas cleaners. Successful control is achieved by the combination of good combustion, followed by the removal of particles from the gases before the latter are discharged to the chimney and the atmosphere. Ash dust in the combustion gases cannot be burned but can be trapped.

Smoke is consumed by combustion of the minute carbon or soot particles to carbon dioxide in the secondary combustion chamber. Larger carbonaceous flakes of paper fall to the floor of the secondary chamber, where the carbon oxidizes away, leaving an ash residue to be removed by periodic cleanout.

The gaseous products of combustion next flow through a gas scrubber or washer where suspended fly ash is largely removed by water spray and wetted surfaces. Water that drains from the scrubber carries these particles to the sewer. Test results on scrubbers of good design indicate that they can meet the standard of 0.2 grains per standard cubic foot of dry flue gas, corrected to 12 per cent CO_2. This standard is equivalent to 0.4 lb of dust per 100 lb of refuse. Gas scrubbers are available to reduce the dust loading of the flue gases to even lower levels where that is required, but at an increase in fan horsepower and water consumption. Incinerator manufacturers will guarantee to meet the legal requirements in all respects.

Gas scrubbers have a further advantage in removing hydrochloric acid vapor from the gases, which result from the combustion of plastics. To counter possible acid attack on the equipment, the recirculated water is treated with small additions of soda ash (Na_2CO_3), or the flow of water to the sewer is increased to reduce the acid concentration in the water.

The discharge gas temperature from the scrubber varies with the scrubber design and the efficiency of scrubbing, and is in the range of 165 to 400 F. To overcome the resistance to flow through the intricate passages of the scrubber and to offset the loss of chimney draft because of the cooling of the gases, scrubbers are provided with exhaust blowers (induced draft fans).

Controls and Safety:

Electrically operated appliances assist the incinerator operator and improve the performance of the installation.

While counterbalanced guillotine charging doors are not burdensome to operate manually, electrically operated doors with push-button control save the operator's time and energy, and reduce his exposure to heat.

The scrubber exhaust fan provides the slight negative pressure in the furnace to induce the inward flow of air required for combustion of the refuse. The flow is regulated by the control damper in the exhaust duct, as well as by proper settings of the air inlet registers.

The gas burners have electric safety controls and can be turned on or off automatically within the set temperature limits.

Should electric power fail when the incinerator is in operation, causing the scrubber and gas burners to shut down, the by-pass damper opens automatically to vent the combustion gases to the chimney.

General Recommendations:

A survey and estimate of present and future refuse generation for a hospital should be prepared in advance of incinerator plant design.

Incinerator room size and shape is determined by the size of equipment to be installed, whether or not a charging platform is included, and the storage space for refuse and residue containers.

Incinerator space, utilities and chimney size should be ample for future hospital expansion. A second incinerator furnace may be necessary in the future.

The Incinerator Standards and other publications of the Incinerator Institute of America should be consulted for general guidance. The Institute's address is 60 East 42nd Street, New York, New York 10017.

The installation should, of course, conform to all regulations, such as building, electrical, air pollution, and other codes.

A qualified professional engineer is usually required to prepare plans for approval by municipal or state agencies which have jurisdiction over the proposed installation or modification. Also, the design of incinerator systems requires knowledge beyond the above simplified presentation.

PYROLYSIS:

Pyrolysis involves the process of destructive distillation or carbonization of solid wastes and results in bulk reduction and the conversion of waste materials to combustible gases and a charred product. Depending upon the characteristics of the waste input, the charred end-product may have commercial value as a useable fuel. Environmental contamination from the pyrolytic process is claimed to be much lower than that produced by incineration. However, since pilot plants are still in experimental stages, the degree of possible atmospheric pollution cannot now be stated.

The theory of pyrolytic action, chemical change induced by heat in the absence of oxygen, is neither new nor unused in certain industries, but its possible application in the treatment of solid wastes has but recently been investigated seriously. In general, materials to be treated are shredded before being fed into a nearly horizontal, cylindrical vessel inside a refractory-lined furnace. A seal is provided to prevent the entrance of air and moisture into the inner drum, or retort. Heat is applied between the outer wall of the slowly rotating retort and the inner walls of the oven.

The products of such pyrolysis are charcoal, combustible gases and some tarry residuals. It is claimed that the gases produced can be utilized to provide some portion of the fuel required to heat the charges in the retort. The extent to which this is possible is not presently known.

A unit being developed by Monsanto Enviro-Chem Systems, Inc. and the Lantz Converter being developed by Pan American Resources, Inc., both employing pyrolysis for solid waste destruction, were inspected during the course of this study.

(Monsanto Enviro-Chem Systems, Inc.)

Increasing resistance to the use of incinerators and the need to develop satisfactory means of the destruction and disposal of general solid wastes have led a major industrial organization to carry out extensive research and experimentation to determine the feasibility of using pyrolysis as a treatment process. Monsanto Enviro-Chem Systems, Inc. is operating a plant in St. Louis County, Missouri, to demonstrate the feasibility of pyrolysis as an economical means of reducing solid waste to an innocuous form. The manufacturer foresees a great potential in waste disposal and recovery of by-products through pyrolysis. Pyrolysis occurs when flammable organic matter is heated to high temperature without air, thus driving off combustible gases and producing a solid residue of charred materials. The flammable, gaseous by-products, burning at high temperatures, generate heat necessary to assure destruction of the odoriferous waste components. It may be possible to utilize the waste heat thus released. The char may be separated and graded for various carbon markets. It is possible also to reclaim other products such as metals and glass, if warranted. Thus, many of the solid waste components may be recovered, recycled and achieve a second use through this process. The Enviro-Chem unit is claimed to be capable of pyrolyzing all types of solid waste, including plastics, rubber and other difficult materials.

The unit appears to provide excellent control of potential pollutants and is acceptable in appearance and operating characteristics. The manufacturers expect these factors to encourage placement of units in light manufacturing or other close-in locations without offense to neighbors.

While cost information on the demonstration plant is incomplete, Monsanto claims that it will be possible to pyrolyze solid wastes at capital and operating costs substantially below those for high quality incineration.

("Lantz Converter" - Pan American Resources, Inc.)

Pan American Resources, Inc. has been operating a Lantz Converter pyrolyzing unit at the Milpitas plant of the Ford Motor Company, near San Jose, California. Here the general industrial dry wastes of the plant are being treated. These wastes are largely composed of wood dunnage, corrugated board and paper products. The corrugated board and much of the paper are being manually separated and baled.

The wooden dunnage and all other remaining wastes are fed by conveyor to a large hammermill for predestruction before introduction into the retort for pyrolyzing. At the PAR installation, the pyrolyzing is reported to require from 12 to 22 minutes for complete conversion to char. Retort temperatures are said to range about 1700 to 2200°F. The residual char is cooled by a water mist spray as it emerges from the retort onto a belt conveyor.

Pan American Resources officials state that there is a ready market for the coarse, granular charcoal. Its market value, early in 1969, was about $35.00 per ton as compared to baled paper which was bringing about $23.00 per ton, F.O.B. Milpitas at this time.

The plant operators claim a capacity of 60 tons of refuse per day, based on a processing rate of 2 1/2 tons per hour. It is further claimed that municipal refuse can be processed but such processing was not witnessed.

WET AIR OXIDATION

Another process for the reduction or conversion of solid wastes is by wet air oxidation. This method has been successfully used for thermal treatment of sewage sludge and produces a sterile slurry that upon dewatering forms a cake which is easily crumbled into granules.

(Zimpro Division of Sterling Drug, Inc.)

The Zimpro Division of Sterling Drug, Inc. produces and markets a processing system designed to reduce the bulk of and to sterilize sewage sludge. The process can be applied to raw or digested, primary or secondary, sludge, plus scum and screenings. The process is claimed to be applicable to industrial waste treatment and disposal.

The wet air oxidation process is based on the principle that any substance capable of burning can be oxidized when in a slurried form under pressure in the presence of air at temperatures between 250°F. and 700°F. The process is especially suited to the treatment of difficult to dewater waste slurries and sludges where the solids are but a few percent of the content.

In the wet air oxidation process, air pollution is controlled when the oxidation takes place in water at relatively low temperatures; hence, no fly ash, dust, sulfur dioxide or nitrogen oxides are formed. An unobjectionable gaseous discharge is assured by passing exhaust gases from the Zimpro unit through a final scrubber or catalytic afterburner. Because water scrubbing of high temperature exhaust gases is not required in wet air oxidation, the heavy steam or water vapor plumes associated with scrubbing systems of incinerators can be eliminated.

As used in the treatment of sludge with a continuous process unit, the sludge is ground to a particle size of 1/4 inch. Sludge and air are then pumped into the system. The mixture is passed through heat exchangers and brought to initiating reaction temperatures between 300° and 400°F. From the heat exchangers, the heated mixture enters a reactor where oxidation takes place at temperatures between 350° and 600°F. The oxidized products leaving the reactor are cooled in the heat exchangers against the entering cold sludge and air. The gases are separated from the liquid carrying the residual oxidized solids and released through a pressure control valve to the catalytic afterburner unit for complete odor control. It may be possible to recover some power from these gases. Upon dewatering the treated slurry with accessory equipment, such as vacuum filters, solids are reduced to about 35% to 45% moisture content.

For startup, heat is obtained from an auxiliary source, usually a small steam generator. With high degree oxidations and high fuel value sludges, no external heat is needed once the process is started.

High pressure units, operating at 1750 psig, have been handling 300 tons of sewage solids per day at the West-Southwest Sewage Treatment Works at Chicago. For small capacity requirements up to about 10,000 gallons of sewage sludge a day, small batch units are available. Dependent upon temperature and pressure ranges, solid waste materials may be merely sterilized by this process or reduced in the conversion process up to about 80% of the original dry weight of solid content of the slurry mix. The manufacturer claims that Zimpro wet air oxidation units will dispose of mixed refuse, including various types of plastics, as readily as any other organic material when properly ground and conditioned in a slurried form.

Among the advantages claimed for the Zimpro process are sterile end products, minimal air pollution, ease of dewatering, a sanitary process which only a closed system can provide and capability of processing a wide range of waste materials in slurried form.

One of the primary objectives of this study has been the consideration of existent and available systems for the efficient handling of the wastes generated in multistory building complexes and hospitals, which would carry solid wastes from their many points of origin to a place or places of ultimate processing or disposal, without human handling or hazards to health. Despite the advanced state of development of general materials handling equipment, tried and proven mechanical components designed exclusively for solid waste handling are almost non-existent, with the exception of chutes and pneumatic conveyor systems. Various types of conveyors used in industry (such as screw conveyors, belt conveyors, chain conveyors, etc.), however, have been adapted to certain components of waste handling and disposal systems.

Various types of processing and disposal equipment (such as compactors, balers, grinders, pulpers, incinerators, etc.), all offering a wide range of capacities, have been developed for solid waste systems in buildings. Continuing improvements are being made in the evolution of this type of equipment.

Reduced space requirements can be accomplished with the use of waste reduction devices, and building sanitation and safety can be improved with modern compactor container storage. Interim storage points in multistory building complexes can be minimized with the use of pneumatic conveyors whereby nearly instant removal of wastes can be accomplished.

Substantial progress is being made in the development of individual components, but generally the total system concept has not yet been developed and marketed, that will provide solutions to all of the many different problems in building complex systems.

A brief recapitulation of the many problems encountered in the building types under study and review of the varieties of equipment available further confirm this observation. This is most emphatically so where a waste system installation is considered for existing structures. The existing layout of floor areas, assigned use and space limitations due to existing mechanical installations impose restrictions upon a free choice of methods and equipment presently available.

The solution to these problems in both existing buildings and those in planning stages requires engineering design of the total system. Design of systems in existing buildings generally requires the following:

1. Analysis of planned building areas and functions and future expansions.
2. Identification of types and quantities of wastes to be generated by building areas.
3. Review applicable code requirements affecting waste handling.
4. Establish range of locally approved disposal methods.
5. Establish range of processing and disposal methods to consider.
6. Establish range of handling methods to consider.
7. Establish range of storage methods to consider.
8. Evaluate economic and environmental aspects of workable combinations of handling, storage and processing.

In addition to the above, design of systems in buildings in the planning stage should also consider the following:

1. Study of general materials handling requirements (quantities and types of new materials at receiving, storage, processing and distribution points).
2. Evaluate merit of common conveyor system for new materials and waste materials.

The rate at which progress is being made in the development of more sophisticated handling and disposal equipment may well make some portions of this report outdated almost before publication. Daily, new material could be added or superseded. It must be recognized that during any period of great technological progress, no precise time could be totally ideal for such a study to be made and the process of updating is a continuing one. New handling methods and treatment processes are being developed, but which are, as yet, untested under working conditions. Some of the equipment known to exist is of foreign origin and not yet installed or proven under operating conditions in the United States. Other equipment or methods, some of which have been seen by the consultant, are still in the development or pilot plant stages and the sponsors have placed restrictions upon disclosure of details at the present time.

In conclusion, it is strongly recommended that continuing investigations be carried out in efforts to stay abreast of developments in this field.

CLASSIFICATIONS AND DEFINITIONS OF EQUIPMENT AND ACCESSORIES

BLOWER - A fan device, operated by an electrical motor and which may be used to exert air movement as pressure or suction. Blowers are used in pneumatic transport systems and have many other applications, some of which may be in the processing of wastes.

BODY, Truck, Special - As used in this report, this term applies to truck bodies of special design which do not fit types otherwise listed.

BUCKET, Clamshell - A digging and transfer device, handled by cables from a crane. It can be opened and closed so as to pick up and hold a mass of material. Some of these buckets are specifically designed for waste handling, especially at incinerators or where loading or unloading of materials of mixed composition and consistency must be accomplished.

CART, Electric - A self-propelled, battery-operated propulsion unit designed to accept and transport various types of modular containers or packaged loads and to do so either attended or unattended. It is capable of horizontal movement following an embedded wire or other type of guide path and can, when properly programmed, call and use specially designed lifts.

CART, Hand-pushed - Any of a large group of wheeled or castered vehicles of light weight and which can be easily handled by an individual. These are fully described in Chapter III, Storage, because many of them serve first as temporary storage units and subsequently as handling devices.

CHUTE, Gravity - Vertical ducts installed in buildings, into which soiled linens or wastes can be inserted and subsequently transported by free-fall to some lower level. They are usually cylindrical in shape and are equipped with hinged doors for the injection of materials to be transported.

COLLECTOR, Litter, Vacuum - A truck-mounted vacuum pump-operated suction mechanism capable of lifting litter and small sized debris through a large diameter, flexible hose and depositing the collected materials into a truck body.

CONVEYOR, Belt - Commonly a transport mechanism employing an endless belt operated over a series of rollers and motivated by electrical motors. Belts may be of cotton, nylon, canvas, rubber impregnated or rubber covered. Conveyors, although usually horizontal, may be inclined nearly twenty degrees.

CONVEYOR, Belt, Mesh - Similar to the more common belt conveyor described above, but equipped with metal mesh belts. They are used to handle hot or cold articles or materials passing through ovens or water sprays, etc. Can be used on plain and "S" curves.

CONVEYOR, Belt, Spring - Similar to the conveyors just defined but its belt is actually a series of endless springs which are sufficiently flexible to permit changes in the conveyor alignment. Usually used on portable conveyors, particularly those used for loading bagged materials.

CONVEYOR, Belt, Wire - Similar to mesh belt conveyors but frequently of heavier metal and used generally for the transfer of bagged materials where it is desired to allow any loose materials to fall through the belt prior to final discharge of the loads carried.

CONVEYOR, Chain, Drag, Driverless - A self-powered, electrical tractor which serves as a driverless motive power unit to haul trains of castered carts by means of a length of chain dragged behind the unit. The chain moves in a channel built into the floor and which has an open top or slot at floor level. The power unit follows the slot and carts are attached to the towed chain by means of drop pins. The unit can be programmed to follow predetermined routes and will stop or start unattended.

CONVEYOR, Chain, In-floor - An endless moving chain moving in a floor channel to which carts can be attached by means of drop pins. The carts can be programmed to drop off at selected turnouts by means of a diverter.

CONVEYOR, Chain, Overhead - An endless moving chain which can be operated horizontally or on an incline, suspended above working areas or in an assigned corridor. Articles and containerized materials can be attached by means of hooks or special carriers. It can be adapted to use with special vertical lifts and programmed to drop off at selected turnouts.

CONVEYOR, Monorail, Electric - A fully automated conveying system employing electrically operated transporters operating on an overhead monorail and carrying special container modules. The system usually operates horizontally in its own tunnels and vertically in special shaftways. Complete programming of call and dispatch of transporters can be automatically controlled by pushbutton. Injection and ejection of modules is also automatic.

CONVEYOR, Pneumatic - A system of tubes which may run horizontally, vertically or diagonally and through which either specially designed tubular carriers, soiled linens or solid wastes, or bulk materials can be transported by air pressure or suction supplied by blowers or fans. Linens or wastes are usually bagged for transport within the system. Naturally, the three types of pneumatic conveyors differ and cannot be used interchangeably to transport materials other than those for which they may be specifically designed.

CONVEYOR, Roller - A common type of conveyor utilizing a series of closely spaced rollers upon which objects or containers can be rolled, largely unattended, from one point to another. Powered rollers are used for lengthy horizontal transport while free, unpowered rollers can be used for very short distances or for sloping conveyors.

CONVEYOR, Screw - A mechanical conveyor consisting of a trough or tube within which a spiral screw revolves to move material from one end of the tube to the other. Although commonly used for horizontal or inclined movement, special designs are available for vertical movement also. This type of conveyor is used for the transport of bulk materials but is adapted to the movement of other materials and slurries as well.

CONVEYOR, Slat - Similar to a belt conveyor, this device has hinged wooden or metallic slats arranged as an endless belt.

CONVEYOR, Sorting - A system frequently utilizing small cars or platforms which circulate on a network of trackage and which is used for the distribution of objects or containers. The platforms or cars are usually capable of tilting so that their contents can be dumped or slid onto other conveyors or delivered to predetermined destinations. The total system is controlled by programming devices and is largely automatic after commands are fed into its controls.

CONVEYOR, Track, Overhead - Although related to the overhead chain type, this conveyor utilizes a series of wheels or rollers jointed into an endless chain which operates within a tube or track which has as its only opening a slot at the bottom. Hooks or carriers may be suspended from the rollers so that loads may be transported.

CONVEYOR, Tramrail - A system of overhead track upon which powered hoist carriers can be moved electrically. The trackage is frequently monorail but for heavier loadings, dual tracks are used. The movement of the carrier on the track and the operation of the crane are controlled by remotely located push buttons.

CONVEYOR, Trolley, Cable - Somewhat similar to the overhead track conveyor, this equipment consists of rollered carriers riding on horizontal or inclined tracks. The carriers are fastened to an endless cable, instead of a chain as in the overhead chain conveyor, and can be spaced to meet specific requirements. Hooks or containers can be suspended from the carriers.

CONVEYOR, Tube - A totally enclosed conveyor for moving bulk or ground materials through a tube. Metal or plastic discs fitting the inside of the tube, spaced several inches apart, and connected by universally jointed endless linkage or chain, are pulled through the tube. Materials injected into the tube are pushed to a desired destination and then ejected. This equipment is sometimes called a drag chain conveyor.

CONVEYOR, Tube, Belt - A method of transport similar to the tube conveyor, this device utilizes an endless, flexible belt which carries materials within a tube, thus keeping the materials dry and preventing spillage. The belt forms into a semi-circular trough during its travel through the tube, but flattens out for its return within a closed pan beneath the tube.

CONVEYOR, Vertical, Continuous - A lifting device consisting of one or more pairs of endless chains operating over pairs of upper and lower pulleys. Carriers are suspended between the chains. Top, bottom and intermediate loading and unloading stations provide for automatic injection and ejection of trays or tote boxes. One side of the chain takes material downward while carriers move upward on the other side.

CONVEYOR, Vertical, Reciprocating - Similar to an elevator, these lifts have trays or other loads injected and ejected from the same side. The dumbwaiter would be classed as a reciprocating, vertical conveyor. This type of equipment can be provided with automatic controls.

CONVEYOR, Wheel - Somewhat similar to roller conveyors but employing several independently movable wheels on a series of closely spaced shafts. Gravity wheel conveyors are frequently used for sorting and accumulation, operations in which the differential actions of the separate wheels are an advantage.

CRANE, Electric - Electrical hoisting device with wide range of size and capacities.

CRANE, Overhead, Monorail - Electric cranes with capability of horizontal movement operating from monorails.

DOLLY, Fiber Glass, Castered - Small, castered platforms made of fiber glass, upon which loads or containers may be readily transported.

DUMBWAITER - Small, light-duty vertical transfer cages which may be powered or hand-operated.

GRAPPLE, Incinerator - A hinged, toothed handling device operated by cables from a crane. Designed to pick up large quantities of materials of a conglomerate nature. Especially intended to handle garbage and trash.

HOIST, Container, Rear-Loading - A special type of hoist which may be cable operated but is generally of the lift-swing-set type and is used for handling large and special shaped containers, which are described in Chapter III. It is mounted on a truck chassis, in place of a body. Containers can be picked up, swung onto the chassis and held there during transport. This hoist and the containers used with it are not to be confused with the hoists and containers commonly used with a mobile packer.

HOIST, Tiltframe, Container, Packer - A tiltable frame equipped with hoisting cables and mounted on a large truck chassis. Hinged at the back of the truck frame, it can be raised at the front, thus allowing large receiving containers, used with stationary packers, to be slid onto or off the tiltframe at the rear of the truck.

LEVELER, Dock - Devices which may be manually, mechanically or hydraulically operated, used to provide a hinged platform between loading docks and trucks to facilitate loading and unloading.

LOADER, Pallet, Automatic - A mechanical tilting device, used in conjunction with conveying systems, to raise or lower loaded pallets or containers from one level to another.

PACKER, Front-Loader, Mobile - A specially constructed truck body, designed to pick up, empty and lower refuse containers of specific design and to compact the refuse dumped into a receiving hopper located topside. This piece of equipment is sometimes called a mobile compactor. The front-loader is intended for use with its own special containers and not to receive cans or bundles of refuse.

PACKER, Rear-Loader, Mobile - A compactor body having a receiving hopper at the rear, into which bagged refuse or containers of loose material can be emptied. The contents of the hopper are subsequently compacted into the main body of the truck. Some models of this packer are equipped with hoisting mechanisms which permit the emptying of special containers into the hopper.

PACKER, Side-Loader, Mobile - A special truck body somewhat similar to the front and rear-loader packers but, as the name implies, it is loaded from the side. Most models will receive only such wastes as may be put into it by hand. However, some models have a hoist for lifting and emptying special containers into the compactor body.

SCOOTER, Collection, Trash - A small, specially designed body mounted on a scooter chassis used for trash collection, generally around building grounds or in inter-building service. The body is equipped with a dumping mechanism.

TAILGATE, Hydraulic - A mechanism, usually hydraulically operated, for raising or lowering heavy or bulky loads from trucks.

TRACTOR, Electric, Driverless, Self-Powered - A battery-operated tractive unit which follows an electric guide path on prearranged routes or is remotely controlled by radio. It is capable of towing trains of castered carts. Electronic programming permits largely unattended operation.

TRACTOR, Electric, Self-powered - A battery-operated tractive unit for towing trains of castered carts. May be capable of accommodating a driver or may be manually controlled with a tiller handle.

TRAILER, Transfer - Mounted on trailers, these large receiving containers can be loaded with compacted wastes at a transfer station and then be hauled to disposal areas. Their large capacities make fewer hauling trips necessary. Refuse is emptied out of the rear of the body.

TAILER, Transfer, Side-tilting - These trailers serve a similar purpose to the transfer trailers just described. Their principal difference is that they are unloaded by being tilted to the side instead of being emptied from the rear.

TRAIN, Container - A series of small, wheeled trash containers can be made into a "train" to be hauled by a small truck or a tractor or tow-motor. This equipment is used generally in inter-building service.

PRODUCT LIST
(Type, Manufacturer and Trade Name)

BLOWER, Air	- Quickdraft Corporation	
BODY, Truck, Special	- Bynal Products, Inc.	- "Hussler"
	- Trashmobile Division Hanna Enterprises	
BUCKET, Clamshell	- Esco Corporation	
CART, Electric, Driverless, Self-powered		
	- Amsco Systems Company Div. of American Sterilizer Co.	- "Amscar"
	- Jervis B. Webb Company	- "Mini-Cart"
CHUTE, Gravity	- Comstock Engineering Co.	
	- Construction Products Co., Inc.	- "Haslett"
	- Kirk & Blum Mfg. Co., The	
	- Lamson Division Diebold, Incorporated	
	- Mathews Conveyor Co.	
	- Olson Div. American Chain & Cable Co., Inc.	
	- Standard Conveyor Co.	
	- Wilkinson Chutes, Inc.	
COLLECTOR, Litter, Vacuum		
	- Truck Equipment Corporation	- "Tecorp"
CONVEYOR, Belt	- Alvey Conveyor Manufacturing Co.	
	- J. L. Baldwin Conveyor Co.	
	- E. W. Buschman Co., The	
	- Comstock Engineering Co.	
	- Conveyor Systems, Inc. A. B. Farquhar Div.	
	- J. C. Corrigan Co., Inc.	
	- Eastern Cyclone Industries, Inc.	- "Air-Flyte"

CONVEYOR, Belt (Continued)
- Hewitt-Robins, Inc.
  Div. Litton Industries
- Hobart Manufacturing Co., The
- Hollymatic Corp.
- Hytrol Conveyor Company, Inc.
- Joy Manufacturing Company
- Kornylak Corporation - "Zipflo" & "Armorbelt"
- Lamson Division
  Diebold, Incorporated
- Link-Belt
  Div. of FMC Corp.
- Mathews Conveyor Company
- Newark Caster & Truck Corp. - "Speedways"
- New London Engineering Co.
- Olson Division
  American Chain & Cable Company, Inc.
- Rapistan Incorporated
- Speedways Conveyors, Inc.
- Sprout, Waldron & Company, Inc.
- Standard Conveyor Company - "Traylift"
- Versa Corp. - "Versa-Veyor"

CONVEYOR, Belt, Mesh
- E. W. Buschman Co., The
- Conveyor Systems, Inc.
  A. B. Farquhar Div.
- Hytrol Conveyor Company, Inc.
- New London Engineering Co.

CONVEYOR, Belt, Spring
- Flexoveyor Conveyor Co.

CONVEYOR, Belt, Wire
- Flexoveyor Conveyor Co.

CONVEYOR, Chain, Drag, Driverless

- SI Handling Systems, Inc. - "Switch-Train"

CONVEYOR, Chain, In-floor

- Anchor Steel and Conveyor Company - "Tow-All"
- E. W. Buschman Co., The
- Link-Belt
  Div. of FMC Corp. - "Trukveyor"
- SI Handling Systems, Inc. - "Lo-Tow" & "Switch-Cart"
- Jervis B. Webb Company - "Shallo-Tow" & "Towveyor"

CONVEYOR, Chain, Overhead

- Anchor Steel & Conveyor Co.
- E. W. Buschman Co., The
- Columbus McKinnon Corporation - "Power-Flex" & "ACTE"
- Conveyor Systems, Inc.
  A. B. Farquhar Div.
- Econo Manufacturing Co.
- Link-Belt
  Div. of FMC Corp. - "Surgamatic"
- Rapistan Incorporated
- Jervis B. Webb Company - "Dog Magic"

CONVEYOR, Monorail, Electric

- Castle Automated Systems
  Division of Sybron Corporation - "Cyberail"

CONVEYOR, Pneumatic

- Aerojet-General Corporation - "AVAC"
- Butler Manufacturing Co.
- Eastern Cyclone Industries, Inc. - "Air-Flyte"
- Fisher-Klosterman, Inc.
- Flo-Tronics
  Air Conveyor Div.
- Fuller Company - "Airveyor"

CONVEYOR, Pneumatic (Continued)
- Lamson Division
  Diebold, Incorporated
- Quickdraft Corporation
- Salina Manufacturing Co., Inc.

CONVEYOR, Roller
- Alvey Conveyor Manufacturing Co.
- Anchor Steel & Conveyor Co.
- E. W. Buschman Co., The
- Conveyor Systems, Inc.
  A. B. Farquhar Div.
- J. C. Corrigan Co., Inc.
- Hytrol Conveyor Company, Inc.
- Lamson Division
  Diebold, Incorporated
- Newark Caster & Truck Corp. - "Speedways"
- Olson Division
  American Chain & Cable Company, Inc.
- Rapistan Incorporated
- Speedways Conveyors, Inc.
- Standard Conveyor Co.
- Versa Corp. - "Versa-Veyor"

CONVEYOR, Screw
- J. C. Corrigan Co., Inc.
- S. Howes Co., Inc.
- Link-Belt
  Div. of FMC Corp.
- Salina Manufacturing Co., Inc.
- Screw Conveyor Corporation
- Sprout, Waldron & Co., Inc.
- Williams Patent Crusher & Pulverizer Co., Inc.

CONVEYOR, Slat
- E. W. Buschman Co., The
- Comstock Engineering Co.
- New London Engineering Co.
- Rapistan Incorporated

CONVEYOR, Sorting - SI Handling Systems, Inc. - "Cartrac"
- Speaker Sortation Systems Division
  Automatic Sprinkler Corp. of America
- Hewitt-Robins, Inc.
  Div. Litton Industries
  Chainveyor Operations

CONVEYOR, Track, Overhead
- Hewitt-Robins, Inc.
  Div. Litton Industries
  Chainveyor Operations
- Jervis B. Webb Company - "Unibilt"

CONVEYOR, Tramrail - Cleveland Tramrail Division

CONVEYOR, Trolley, Cable
- E. W. Buschman Co., The

CONVEYOR, Tube - Hapman Corp.
- Prab Conveyors, Inc.
- Jervis B. Webb Company - "Tube-Flo"
- Sprout, Waldron & Co., Inc.

CONVEYOR, Tube, Belt
- Con-Vey International, Inc. - "Tube-Belt"

CONVEYOR, Vertical, Continuous
- Alvey Conveyor Manufacturing Co.
- E. W. Buschman Co., The
- Conveyor Systems, Inc.
  A. B. Farquhar Div.
- Hewitt-Robins, Inc.
  Div. Litton Industries
  Chainveyor Operations
- Kornylak Corporation - "Vertiflo"
- Lamson Division
  Diebold, incorporated

CONVEYOR, Vertical, Continuous (Continued)
- Olson Division
  American Chain & Cable Company, Inc.
- Rapistan Incorporated
- Standard Conveyor Co. - "Escaveyor"
- Jervis B. Webb Company

CONVEYOR, Vertical, Reciprocating
- Anchor Steel & Conveyor Co.
- J. L. Baldwin Conveyor Co.
- E. W. Buschman Co., The
- Conveyor Systems, Inc.
  A. B. Farquhar Div.
- Lamson Division
  Diebold, Incorporated
- Olson Division
  American Chain & Cable Company, Inc.
- Rapistan Incorporated
- Jervis B. Webb Company

CONVEYOR, Wheel
- E. W. Buschman Co., The
- Conveyor Systems, Inc.
  A. B. Farquhar Div.
- Hytrol Conveyor Co., Inc.
- Kornylak Corporation
- Olson Division
  American Chain & Cable Company, Inc.
- Rapistan Incorporated
- Speedways Conveyors, Inc.
- Versa Corp. - "Versa-Veyor"

CONVEYOR, Wicket-type
- Conveyor Systems, Inc.
  A. B. Farquhar Div.

CRANE, Electric
- Harnischfeger Corp. - "P&H"

CRANE, Overhead, Monorail
- Cleveland Tramrail Division of Cleveland Crane & Eng. Div. of McNeil Corp. - "Tarca Track"

DOLLY, Fiber Glass, Castered
- Container Development Corp.

DUMBWAITER - J. L. Baldwin Conveyor Co.

GRAPPLE, Incinerator - Esco Corporation
- Jos. F. Kiesler Company

HOIST, Container, Rear-Loading
- Bremen Equipment Corp.
- Bynal Products, Inc. - "Tripsaver"
- Converto Mfg. Co. Div. of Golay & Co., Inc. - "Convertainer"
- Dempster Brothers, Inc. - "Dumpster"
- Heil Co., The - "Load Lugger"
- Perfection-Cobey Company Div. of Harsco Corp. - "Liftainer"
- Western Body & Hoist Co.

HOIST, Tiltframe, Container, Packer
- Anchor Machine Company, Inc. - "Anchorlift"
- S. Vincen Bowles, Inc.
- Converto Mfg. Co. Div. of Golay & Co., Inc. - "Leav-A-Tainer"
- Dempster Brothers, Inc. - "Dinosaur"
- E-Z Pack Company
- Gar Wood Industries, Inc. - "Dispos-Haul"
- Heil Co., The - "Huge-Haul"
- Hobbs Hyd-Pak Div. of Fruehauf Corp. - "Pack-Saddle"
- Industrial Services of America Tri-Pak Division - "Tri-Pak"

HOIST, Tiltframe, Container, Packer (Continued)		
	- King Container, Inc.	
	- Perfection-Cobey Company Div. of Harsco Corp.	- "Fleetainer"
	- Swiftainer Industries Corp.	- "Swift-Hoist"
	- Universal Handling Equipment Co.	
	- Wayne Engineering Corporation	
	- Western Body & Hoist Co.	
LEVELER, Dock	- T&S Equipment Company	- "Dockmate"
PACKER, Front-Loader, Mobile		
	- Dempster Brothers, Inc.	- "Dumpmaster"
	- E-Z Pack Company	
	- King Container, Inc.	
	- LoDal, Inc.	- "Load-A-Matic"
	- Pak-Mor Manufacturing Co.	
	- Perfection-Cobey Company Div. of Harsco Corp.	- "Pak-tainer" & "Fork-tainer"
	- Western Body & Hoist Co.	- "Full-Pak", "Jet Full-Pak" & "Top-Pak"
PACKER, Rear-Loader, Mobile		
	- City Tank Corp.	- "Load-Master" & "Roto-Pac"
	- Elgin Leach Corp.	- "Packmaster"
	- E-Z Pack Company	
	- Gar Wood Industries, Inc.	
	- Heil Co., The	- "Colectomatic"
	- Hobbs Hyd-Pak Div. of Fruehauf Corp.	- "Hyd-Pak"
	- Pak-Mor Manufacturing Co.	- "Load Liner"
	- Perfection-Cobey Company Div. of Harsco Corp.	- "Cobey"
	- Tampo Mfg. Co., Inc.	- "Seal-Press"

PACKER, Side-Loader, Mobile		
	- D-V Metal Fab Co. Div. of Data-Veyors Corp.	- "Fastpack"
	- E-Z Pack Company	
	- Hobbs Hyd-Pak Div. of Fruehauf Corp.	- "Com-Pak"
	- Pak-Mor Mfg. Co.	
	- Perfection-Cobey Company Div. of Harsco Corp.	- "Swift-Pak"
	- H. E. Smith, Inc.	- "Smithpac"
	- Sterling Mfg. Co.	- "Hippo"
	- Tampo Mfg. Co., Inc.	- "Seal-Press"
	- Truck Equipment Corp.	- "Truxmore Pakker"
	- Val-Jac Mfg. Co., Inc.	- "Pak-Rat"
	- Wayne Engineering Corp.	- "Mighty-Pack"
	- Western Body & Hoist Co.	- "Shu-Pak"
PACKER, Trailer	- Dempster Brothers, Inc.	
	- Elgin Leach Corp.	
	- Gar Wood Industries, Inc.	
	- King Container, Inc.	
	- M-B Company	- "Moto-Pack"
	- H. E. Smith, Inc.	- "Portapac"
	- Val-Jac Mfg. Co., Inc.	- "Pak-Rat-Pup"
	- Wayne Engineering Corp.	- "Mighty-Pack"
SCOOTER, Collection, Trash		
	- Cushman Motors	
	- Truck Equipment Co. of Georgia, Inc.	- "Trash Taxi"
TAILGATE, Hydraulic	- Heil Co., The	- "Heil-A-Way"
TRACTOR, Electric, Driverless, Self-powered		
	- Barrett Electronics Corporation	- "Guide-O-Matic" & "Radox"
	- Jervis B. Webb Company	- "Prontow"

TRACTOR, Electric, Self-powered
- Barrett Electronics Corporation

TRAILER, Transfer
- S. Vincen Bowles, Inc.
- Dempster Brothers, Inc.
- Elgin Leach Corporation
- Heil Co., The
- Hobbs Hyd-Pak
  Div. of Fruehauf Corp.
- Pak-Mor Mfg. Co. - "Lo Boye"
- Swiftainer Industries Corp. - "Swiftransfer"

TRAILER, Transfer, Side-tilting
- Gar Wood Industries, Inc.

TRAIN, Container
- LoDal, Inc.
- Truck Equipment Corporation - "Trux-Train"

CLASSIFICATIONS AND DEFINITIONS OF EQUIPMENT AND ACCESSORIES

BOX, Tote - Small containers, usually open, made of various metals, fibers or plastics. Used for moving small quantities of materials and usually associated with conveying systems. Capacities of one and a half to about three cubic feet.

CART, Hand-Pushed - Two or four wheeled or castered vehicles made of metal or plastic, used to transport wastes or other materials or supplies by hand-pushing. Small in sizes and capacities but may have shelves, bins or other special-use compartments.

CART, Trash, Packer - Large, heavy duty castered bins, having capacities of about two to five cubic yards. Capable of being made into trains for hauling to processing points. Used with special, heavy duty dumping devices in connection with stationary packers.

CONTAINER, Mobile-Packer - Medium duty refuse bins or boxes so designed as to permit their being mechanically raised by and emptied into a mobile packer. Various designs allow use with front, rear or side loading packers. Capacities will range from about one to eight cubic yards. These containers are usually fitted with hinged tops and/or sides. Those styles designed for use with small, apartment-size stationary packers may be as small as one cubic yard.

CONTAINER, Open-Top - Large, open-top boxes with capacities up to forty cubic yards, used for hauling uncompacted and bulky wastes. The box-like body is of the roll-on, roll-off type, handled by a tiltframe hoist mounted on a truck chassis. The containers are rear-dumping.

CONTAINER, Rear-Loading - Large, special shaped containers of capacities from 1 1/2 to 16 cubic yards, used to handle loose, bulk or wet materials. They can be hand, machine or chute loaded. Containers must be handled by a special hoist mounted on a truck chassis and are dumped from the rear by the special hoist.

CONTAINER, Receiving, Stationary-Packer - Large capacity, ranging from six to over sixty cubic yards, these containers are closed boxes which are secured to stationary packers and into which the loose wastes are compacted by the packer ram mechanism operating through a relatively small aperture in one end of the container.

HOLDER, Bag, Disposable - Devices, usually of metal, from which empty paper or plastic bags can be suspended for filling purposes. May or may not be equipped with a cover.

HOPPER, Self-dumping - Steel bins or containers designed for dumping accumulated scrap or refuse by means of a lifting action. Can be used in conjunction with a fork lift or other handling device. Capacities from 3/8 to 4 cubic yards.

HOPPER, Vibrating - Hoppers with built-in agitating mechanisms to facilitate steady and regulated material flows.

HOPPER, Weighing, Air-operated - A hopper designed to feed measured weights of materials in processing systems utilizing air transport.

LINER, Can, Plastic - Plastic bags used to line cans or barrels to promote cleanliness or ease of subsequent handling of wastes or other materials.

WASHER, Can - Device for washing and sterilizing waste cans.

PRODUCT LIST
(Type, Manufacturer and Trade Name)

BAG, Cloth, Reusable	Industrial Bag & Spec., Inc.	
BAG, Laundry, Soluble	Mono-Sol Div. Chris Craft Industries, Inc.	
BAG, Paper, Disposable	Gilman Paper Co.	"DisPOzit"
	International Paper Co.	"Garbax"
	St. Regis Paper Co.	
	Union Camp Corp.	
	West Virginia Pulp and Paper Co.	"Westvaco"
BAG, Plastic, Disposable	Mobil Chemical Co.	
	Phillips Films Co., Inc. Polyolefin Div.	"Piggie Pokes"
	Rubbermaid Commercial Products, Inc.	
BARREL, Aluminum	Grand Aluminum Welding	
BARREL, Fiber	William Bal Corp.	
	Metal Edge Industries	"Fiberoc"
BARREL, Plastic	Chilite Plastics, Inc.	"Chilite Toter"
	County Plastics Corp.	
	Refuse Disposal Equipment Co., Inc.	"Aerospace"
	Rubbermaid Commercial Products, Inc.	"Brute Group"
	Florsheim Mfg. Co., Inc.	
BARREL, Steel	Republic Steel Corp.	
BOX, Tote, Aluminum	McClintock Division Unarco Industries, Inc.	
	Wear-Ever Aluminum Co.	

BOX, Tote, Fiber	William Bal Corp.	
	Insulfab Container Corporation	
	Metal Edge Industries	"Fedco"
	Newark Caster & Truck Corp.	
BOX, Tote, Fiber Glass	Container Development Corp.	
	Molded Fiber Glass Tray Co.	"MFG Toteline" & "Toteline"
BOX, Tote, Plastic	Container Development Corp.	
	Gould Products, Inc.	
	Hollywood Plastics, Inc.	
	McClintock Division Unarco Industries, Inc.	
	Metropolitan Wire Goods Corp.	
	Uniroyal, Inc.	"Royalite"
BOX, Tote, Steel	Fort Steuben Metal Products Co.	
	Republic Steel Corp.	
CART, Aluminum, Hand-pushed	McClintock Division Unarco Industries, Inc.	
	Rol-Away Truck Mfg. Co., Inc.	
CART, Fiber Glass, Hand-pushed	Container Development Corp.	
CART, Fiber, Hand-pushed	William Bal Corp.	
	Insulfab Container Corp.	
	Metal Edge Industries	
CART, Packer, Stationary	Anchor Machine Co., Inc.	"Anchortilt"
	E-Z Pack Company	"E-Z Kart"
	Industrial Services of America	"Tri-Pak"
	Swiftainer Industries Corp.	

CART, Refuse, Tiltable, Plastic

- Fusion Rubbermaid Corp. - "Tilt-Truck"

CART, Side-Loader, Packer, Mobile

- Hobbs Hyd-Pak - "Hyd-Pak"

CART, Steel, Hand-pushed

- Bloomfield/Silex Industries, Inc.
- Fort Steuben Metal Products Co.
- McClintock Division
  Unarco Industries, Inc.
- Metropolitan Wire Goods Corp.
- Rapistan Incorporated - "Wheel-Ezy"
- Republic Steel Corp.
- Tradewind Industries, Inc.

CONTAINER, Front-Loader, Packer, Mobile

- Burtman Iron Works - "Dyna-Bilt"
- Bynal Products, Inc. - "Hand-E-Con"
- Dempster Brothers, Inc.
- E-Z Pack Company
- Gen Sani-Can Corporation
- King Container, Inc.
- LoDal, Inc. - "Load-A-Matic"
- National Compactor & Technology
  Systems, Inc.
- New York Sani-Can, Inc.
- Pak-Mor Manufacturing Co.
- Universal Handling Equipment Co.

CONTAINER, Open-top

- Bremen Equipment Corp.
- Gar Wood Industries, Inc. - "Dispos-Haul"
- Heil Co., The - "Huge-Haul"

CONTAINER, Rear-Loader, Packer, Mobile

- Apex Metal Products	
- Burtman Iron Works	- "Dyna-Bilt"
- Bynal Products, Inc.	- "Hand-E-Con"
- Elgin Leach Corporation	
- E-Z Pack Company	
- Gen Sani-Can Corp.	
- King Container, Inc.	
- National Compactor & Technology Systems, Inc.	
- New York Sani-Can, Inc.	
- Pak-Mor Manufacturing Co.	
- Universal Handling Equipment Co.	

CONTAINER, Rear-Loading

- Apex Metal Products	- "Spill-Tainer"
- Bynal Products, Inc.	
- Converto Mfg. Co.	
- Dempster Brothers, Inc.	
- Heil Co., The	- "Load Lugger"
- Perfection-Cobey Company	

CONTAINER, Receiving, Packer, Stationary

- Anchor Machine Co., Inc.	- "Anchortainer"
- Auto Pak Co.	- "Dual-Pak"
- S. Vincen Bowles, Inc.	
- Dempster Brothers, Inc.	
- E-Z Pack Company	
- Heil Co., The	- "Huge-Pac"
- Hobbs Hyd-Pak	
- Industrial Services of America	- "Tri-Pak"
- King Container, Inc.	
- Marathon Equipment Co., Inc.	- "Ram-Jet"
- National Compactor & Technology Systems, Inc.	
- New York Sani-Can, Inc.	
- Swiftainer Industries Corp.	- "Swiftainer"
- Tubar Waste Systems	- "Tubartainer"

CONTAINER, Side-Loader, Packer, Mobile		
	Burtman Iron Works	"Dyna-Bilt"
	Bynal Products, Inc.	"Hand-E-Con"
	Gen Sani-Can Corp.	
	Hobbs Hyd-Pak	
	King Container, Inc.	
	National Compactor & Technology Systems, Inc.	
	Pak-Mor Manufacturing Co.	"Handi-Lift"
	Tampo Manufacturing Co., Inc.	"Seal-Press"
	Truck Equipment Corp.	"Truxmore Container"
	Universal Handling Equipment Co.	
	Val-Jac Manufacturing Co., Inc.	
HOLDER, Bag, Paper, Disposable		
	Gilman Paper Co.	"DisPOzit"
	International Paper Company	"Garbax"
	St. Regis Paper Co.	
	Union Camp Corp.	"Trim-Town"
	West Virginia Pulp & Paper Co.	"Papercan"
HOPPER, Feeder, Vacuum		
	Vac-U-Max	"Jet-Air"
HOPPER, Self-Dumping		
	Bremen Equipment Corp	
HOPPER, Vibrating	Carman Industries, Inc.	
	Vibra Screw, Inc.	
HOPPER, Weighing	Stedman Foundry and Machine Co., Inc.	
HOPPER, Weighing, Air-operated		
	Vac-U-Max	

LINER, Can, Plastic - See Bag, Plastic

WASHER, Can - Atomic Disposer Corp. - "Waste-O-Matic" & "Cleen-O-Matic"
- Sargent NCV Division Zum Industries, Inc.
- Vacuum Can Company

CLASSIFICATIONS AND DEFINITIONS OF EQUIPMENT AND ACCESSORIES

BALER, Portable - Commercial capacity, hydraulic compaction devices, caster-mounted for towing or pushing or may be mounted on self-powered vehicles.

BALER, Stationary - These machines may be of either the vertical or horizontal types. They may be hand or chute-fed and require some sort of final containment, such as strapping, bagging or boxing, to hold the compacted materials in compression. All types require some manual attention. They vary in sizes, capacities and methods of containment. Some subclassifications of stationary balers are those specifically designed for use in hospitals, apartments and industry.

CHIPPER, Brush - A towable machine employing cutting knives revolving at very high speed, used to reduce brush and small tree limbs to chips. The chipper is equipped with a blower for pneumatically transporting the chipped wood into a truck or other container.

COLLECTOR, Dust - These devices may be of several types and are designed to separate dust and other particulates from air streams before discharge of air to the atmosphere. Cyclone-type collectors used in processing, to separate solids from the air stream, are further defined under separators.

COLLECTOR, Fume - Equipment designed to trap and remove noxious fumes from processing operations.

CONTROLS - Photoelectric, magnetic, electric, mechanical and pneumatic devices which may operate singly or in groups for the control of operating mechanisms in handling, storage, processing or disposal systems. These also include safety devices for detecting the presence of smoke in chutes or ducts and malfunctions of components of systems. They may cause audible and/or visible alarms or shut off operating mechanisms.

CRUSHERS - Heavy duty mills used in industry for size reduction of friable materials. They may be of various designs including rolling ring, fixed or rotating knives, star knives or impact devices of several shapes. Trade nomenclature for this type of machine includes grinder, pulverizer, hammermill, etc. In general, crushers may be classed as hammermills of either fixed or movable knife design. The primary distinction between crushers, grinders and pulverizers, as opposed to shredders, is that the former reduce particle sizes of brittle materials. The latter are more effective with non-brittle materials.

CRUSHER, Bottle - A machine designed to crush bottles into fragments by the application of pressure between plates, jaws or rollers.

CRUSHER, Can - A crushing device similar to a bottle crusher but one which flattens cans rather than fragmentizes them.

CRUSHER, Delumper - A small crusher employing fixed knives rotating through a steel comb used to remove lumps from dry materials. It is small in size and designed for use in the chemical industry.

CRUSHER, Syringe - A small, table-mounted machine for destroying plastic one-time use syringes by crushing.

DELUMPER, Pipeline - A crusher with revolving blades and comb teeth, similar to the delumper crusher previously described, but built to be fitted into a pipeline for size reduction of wet materials flowing through process piping.

DETECTOR, Metal - A magnetic device used to detect even very fine metallic particles in products being processed. Can be mounted on conveyors.

DIGESTER, Continuous - Generally, a cylindrical tube containing a screw conveyor for cooking, or digesting, wet materials in the chemical, food processing, paper and other industries.

DRYER, Fluid Bed - A unit designed to dry, cool, calcinate, pelletize or blend materials by the application of high heat utilizing gases to suspend and agitate a bed of granular solids. It has many industrial applications.

DRYER, Rotary - Rotary dryers are also known as kilns and are used for both drying and cooling various types of materials. They are generally horizontal tubes which revolve inside a heated container. In certain applications, heat is emitted within the tube to dry the materials being processed. Slope is provided so that materials placed inside the revolving tube for drying will flow at a controlled rate from one end of the tube to the other.

EXTRACTOR, Screw - A device employing the screw principle, used to separate solid materials from liquids. The chemical and pulp processing industries use this equipment. It is also used in solid waste systems for dewatering pulped or wet ground waste materials.

EXTRUDER, Refuse - A component used with certain types of dry grinders to compact finely ground, moist refuse into briquettes. Some are made integral with the grinder and others are designed as optional additions.

GRINDER, Dry - These mills are related to the crushers previously defined and may also be classified by manufacturers as pulverizers or hammermills. Similar to crushers and frequently indistinguishable from them, they may have fixed or movable blades or hammers. They are used to grind brittle materials by impact.

GRINDER, Wet - This classification includes the food waste grinders used in special sinks or with large hoppers. They are commonly found in the dietary areas of institutions, such as hospitals.

HAMMERMILL - The name hammermill is applied to a wide variety of mills whose functions are the crushing of friable materials such as coal, rock and mixed materials. Some types of hammermills can also be used to destruct nonfriable materials, including solid wastes. These mills can be of several designs, each different from others, and still be considered by manufacturers as hammermills. The hammers may be fixed or movable. The mill can be of the down-running or over-running type. Breaker plates may be fixed or traveling. The basic design is a horizontal shaft to which are attached the fixed or movable hammers. Shaft speeds may vary from 1500 to 360 r.p.m. and hammer velocities from 5,000 to 20,000 feet per minute. The hammermill breaks materials primarily by impact rather than by crushing or grinding between two hard surfaces.

HOGGER - The hogger, sometimes called wood hog, blow hog or hog, is also considered a hammermill by some manufacturers. Although usually associated with the reduction of large pieces of wood to chips or shavings, the hogger can be used for breaking solid wastes into small particles or shreds. Its construction is similar to the hammermills previously described but is commonly equipped with rotating hammers instead of fixed knives.

MIXER - Mechanical mixers, as differentiated from pneumatically operated blenders or mixers, are of two general types. One, resembling a concrete mixing drum, is used in the processing of dry materials by a tumbling action. A vertical mixer is also available. A screw operating in the center of a cylinder raises and intermixes dry materials introduced at either the top or bottom of the cylinder.

PACKER, Roll-off - A packer similar to a stationary packer but mounted on skids and equipped with heavy rollers so that it may be rolled onto or off a truck equipped with a tiltframe hoist.

PACKER, Stationary - Sometimes called a fixed packer, this equipment receives and compacts loose wastes which may be manually or mechanically fed to it. The packer remains in a fixed location. It packs the refuse into a large, closed container which, when full, is hauled away to a disposal area and emptied. The haulaway trucks are equipped with tilt-frame hoists previously described. The full receiving container is replaced with an empty one so that the storage and compaction operations are but briefly interrupted.

PACKER, Trailer - A compaction unit combined with a receiving container which can be trailed behind a truck or tractor. When the container is full, it is hauled to a disposal area and the compacted load is pushed out of the rear of the container by the packer ram.

PACKER, Transfer, Stationary - A fixed packer used at a transfer station. Mobile packers empty their collected loads into the transfer packer, which in turn compacts the wastes into large transfer trailers for hauling to disposal areas.

PRECIPITATOR, Electrostatic - A device using opposite electrostatic charges to attract, separate and precipitate fine dust or liquid particles, fumes, fogs or corrosive gases. Employed to reduce or eliminate objectionable emissions from processing plants.

PRESS, Dewatering - A machine employing single or dual rotating screws to dewater or thicken high-moisture, fibrous materials such as various types of pulp.

PULLEY, Magnetic - A pulley equipped with one or more electromagnetic coils and used in connection with belt conveyors for the separation of tramp metal from materials being handled in processing.

PULPER - A machine employing the combined principles of mechanical and hydraulic shearing to destruct solid materials into a pulp. A rotor is mounted in the bottom of a bowl into which water and the materials to be pulped are introduced. The rotating impeller creates a hydraulic vortex, drawing the materials downward. A perforated bedplate below the rotor determines the sizes of particles of pulped material which passes through it and out of the pulper, since all liquids and solids must exit through it. Pulpers can be combined with junk removers and dewatering presses and are sometimes used in a process for the reduction of solid wastes.

PULVERIZER - A mill similar to hammermills, crushers and grinders and used to reduce the size of friable materials. These machines are usually associated with finer grinding than grinders or crushers, even though they frequently employ the same principles of reduction.

PULVERIZER, Paper - A specially designed machine for the reduction of paper. The process is also called "dry pulping". The equipment employs a swing-type hammermill which also has a built-in pre-grinding shredder. The end product is a fine textured, cotton-like powder.

SEPARATOR, Cyclone - Cyclones, as they are commonly called, are usually vertical cylinders with an inverted bottom section through which air streams are passed for the purpose of removing fine particles of dry materials carried in suspension. The cyclone operates on the principle of inertial separation. Some types of cyclones have a large number of small cyclonic units arranged in parallel.

SEPARATOR, Magnetic - Any of a variety of magnetic plates or grates used to remove ferrous metals from materials passing over or under them. Used in connection with conveying systems.

SHREDDER - Shredders are mills similar to hammermills, crushers, grinders or pulverizers in their operation. They may have fixed or swing hammers or knives. The design and shape of the hammers may differ from some other types of mills. The term shredder is usually applied to mills which are to be used for the destruction of paper, rags and other non-brittle materials.

SHREDDER, Screenings, Sewage - A hammermill-type of shredder designed for the reduction of sewage solids. They are commonly used in connection with bar screens and produce uniform particle sizes of materials passed through them.

SIEVE, Dewatering - A non-mechanical device over which slurries or pulped materials can be passed for removal of excess liquids and thickening of slurries being processed.

STERILIZER, Sludge - Equipment or system of equipment components for neutralization of contaminated sludges without oxidation or destruction occurring. May involve chemical or thermal processes in the treatment of industrial wastes and sewage sludge.

STRAINER, Line - Large basket-type strainers for the removal of objectionable materials from liquids being processed and handled through pipelines.

PRODUCT LIST

(Type, Manufacturer and Trade Name)

BALER, Bag-type	Automatic Refuse Systems, Inc.	"ARS"
	Auto Pak Co.	"Gobbler"
	Compaction Equipment Co., Inc.	"Gator"
	E-Z Pack Company	
	Piezo Manufacturing Corp.	"Piezo-Pak"
	Waterbury Hydraulics Industries, Inc.	
BALER, Carousel-type	Loewy Machinery Supplies Co., Inc.	"Loewy-Kompex Carousel"
	Research-Cottrell, Inc.	"Pak-Trell"
BALER, Continuous	American Baler Co., The	
	Balemaster Div. East Chicago Machine Tool Corp.	"Cyclomatic"
	Logemann Bros. Co.	
	Maren Engineering Corp.	
BALER, Portable	Maren Engineering Corp.	
	Tamaker Corp.	
BALER, Stationary	American Baler Machine Co. Div. Nat'l Compactor & Technology Systems, Inc.	
	Compackager Corporation	
	Consolidated Baling Machine Co.	
	Logemann Bros. Co.	
	Tamaker Corp.	
BLENDER	Sprout, Waldron & Co., Inc.	
	Strong-Scott Mfg. Co., The	
	Sturtevant Mill Co.	
CHIPPER, Brush	Wayne Manufacturing Co.	

COLLECTOR, Dust, Bag-type	- John Zink Co.	
COLLECTOR, Dust, Centrifugal	- Fisher-Klosterman, Inc.	- "Balanced Air" & "Cluster-Clone"
COLLECTOR, Dust, Cyclone	- Bartlett-Snow	
	- Fisher-Klosterman, Inc.	- "Balanced Air" & "Cluster-Clone"
	- Salina Manufacturing Co., Inc.	
COLLECTOR, Fume	- Fisher-Klosterman, Inc.	- "Balanced Air"
CONTROL, Photoelectric	- Autotron, Inc.	
CONTROL, Proximity	- Autotron, Inc.	
CONTROLS, Electric	- Farmer Electric Products Co., Inc.	
CONTROLS, Motor, Electric	- Saco Electronics Corporation	
CONTROLS, Ultrasonic	- Delavan Manufacturing Co.	
CRUSHER	- American Pulverizer Co.	
	- Gruendler Crusher and Pulverizer Co.	
	- Hammermills, Inc.	- "Bull Dog"
	- Pennsylvania Crusher Corp.	
	- Sprout, Waldron & Co., Inc.	
	- Stedman Foundry and Machine Co., Inc.	
	- Sturtevant Mill Co.	
	- Williams Patent Crusher and Pulverizer Co., Inc.	
CRUSHER, Bottle	- Qualheim, Inc.	

CRUSHER, Can	Qualheim, Inc.	
CRUSHER, Delumper	Franklin Miller, Inc.	
CRUSHER, Syringe	Qualheim, Inc.	
DELUMPER, Pipeline	Franklin Miller, Inc.	
DETECTOR, Metal	Indiana General Magnetic Equipment Div.	
DETECTOR, Smoke	Autotron, Inc.	
DIGESTOR, Continuous	Black Clawson Company, The	"Chemi-Pulper"
DRYER, Fluid Bed	Bartlett-Snow	
	Strong-Scott Manufacturing Co., The	
DRYER, Rotary	Bartlett-Snow	
EXTRACTOR, Screw	Bauer Bros. Co.	
EXTRUDER, Refuse	Electronic Assistance Corp.	"EAC/Refuse Compactor"
	Mil-Pac Systems, Inc. Unit of SMF Corporation	
FEEDER, Belt	Williams Patent Crusher & Pulverizer Co., Inc.	
FEEDER, Gravimetric	Howe Richardson Scale Co.	
FEEDER, Vacuum	Vac-U-Max	"Jet-Air"
FEEDER, Vibrating	Carman Industries, Inc.	
	Hammermills, Inc.	
	Syntron Div. of FMC Corp.	
	Vibra Screw, Inc.	

GRINDER, Dry	- Buffalo Hammer Mill Corp.	
	- Eidal International Corp.	- "Mini-Mill"
	- Electronic Assistance Corp.	- "EAC/Refuse Compactor"
	- Gruendler Crusher and Pulverizer Co.	
	- Mil-Pac Systems, Inc. Unit of SMF Corporation	
	- Williams Patent Crusher and Pulverizer Co., Inc.	
GRINDER, Wet	- Atomic Disposer Corp.	
	- Buffalo Hammer Mill Corp.	
	- Bus Boy Disposer, Inc.	
	- FMC Corporation	
	- Gruendler Crusher & Pulverizer Co.	
	- In-Sink-Erator Mfg. Co.	
	- Salvajor Company	
	- Swimquip Inc.	
	- Waste King Universal	
HAMMERMILL	- American Pulverizer Co.	
	- Bauer Bros. Co.	
	- Buffalo Hammer Mill Corp.	
	- Gruendler Crusher and Pulverizer Co.	
	- Hammermills, Inc.	- "Bull Dog"
	- Sprout, Waldron & Co., Inc.	
	- Stedman Foundry and Machine Co., Inc.	
	- Sturtevant Mill Company	
	- Williams Patent Crusher & Pulverizer Co., Inc.	
	- W-W Grinder Corp.	
HOGGER	- Balemaster Div. East Chicago Machine Tool Corp.	- "Cyclomatic"
	- Ecology Industries, Inc.	
	- Gruendler Crusher & Pulverizer Co.	
	- Logemann Bros. Co.	
	- Stedman Foundry & Machine Co., Inc.	- "Nife-Less"
	- Williams Patent Crusher & Pulverizer Co., Inc.	- "No-Nife"

MIXER	Sprout, Waldron & Co., Inc.	
	Stedman Foundry and Machine Co., Inc.	
	Sturtevant Mill Co.	
PACKER, Roll-off	S. Vincen Bowles, Inc.	"Bowles Pac"
PACKER, Stationary	Anchor Machine Company, Inc.	"Anchorpac"
	Apex Metal Products Div. of Hydraulic Refuse Systems Corp.	"Concentrator"
	Auto Pak Co.	"Dual-Pak" & "Pitch 'N Pak"
	S. Vincen Bowles, Inc.	"Bowles Pac"
	Compaction Equipment Co., Inc.	"Pac-King"
	Dempster Brothers, Inc.	"Dinopacker II"
	E-Z Pack Company	
	Heil Co., The	"Huge-Pac"
	Hobbs Hyd-Pak Div. of Fruehauf Corp.	"Hyd-Pak"
	Industrial Services of America Tri-Pak Division	"Tri-Pak"
	King Container, Inc.	
	LoDal, Inc.	
	Marathon Equipment Co., Inc.	"Ram-Jet"
	National Compactor & Technology Systems, Inc.	
	New York Sani-Can, Inc.	"Sani-Pac"
	Pak-Mor Mfg. Co.	
	Perfection-Cobey Company Div. of Harsco Corp.	"Station-pak"
	Swiftainer Industries Corp.	"Swift-Pac"
	Tubar Waste Systems, Div. Uhrden, Inc.	"Tubar-Pak"
	Universal Handling Equipment Co.	
	Western Body & Hoist Co.	"Shu-Pak"

PRECIPITATOR, Electrostatic	Nichols Engineering & Research Corp.	
	John Zink Co.	
PRESS, Dewatering	Bauer Bros. Co., The	"Pressafiner"
PULLEY, Magnetic	Indiana General Magnetic Equipment Div.	
PULPER	Black Clawson Company, The	
	Somat Corp.	
	Wascon Systems, Inc.	
PULVERIZER	Bauer Bros. Co.	
	Gruendler Crusher and Pulverizer Co.	
	The Heil Co.	"Tollemache"
	Stedman Foundry and Machine Co., Inc.	
	Sturtevant Mill Co.	
PULVERIZER, Paper	Pacific Cutter Co., Inc.	
	W-W Grinder Corp., The	
PUMP, Slurry	Hammermills, Inc.	
SCALE	Howe Richardson Scale Co.	
SCREEN, Vibrating	Bauer Bros. Co.	
	S. Howes Co., Inc.	
	Sprout, Waldron & Co., Inc.	
	Stedman Foundry & Machine Co., Inc.	
	Williams Patent Crusher & Pulverizer Co., Inc.	
SEPARATOR, Cyclone	Balemaster Div. East Chicago Machine Tool Corp.	
	Eastern Cyclone Industries, Inc.	"ECI" & "Air-Flyte"
	Gruendler Crusher & Pulverizer Co.	
	Quickdraft Corporation	

SEPARATOR, Cyclone (Continued)
- Salina Manufacturing Co., Inc.
- Williams Patent Crusher & Pulverizer Co., Inc.
- John Zink Company

SEPARATOR, Magnetic
- Bunting Magnetics Co.
- Indiana General
  Magnetic Equipment Div.
- W-W Grinder Corp., The

SHREDDER
- American Baler Co., The
- American Pulverizer Co.
- Gruendler Crusher & Pulverizer Co.
- Hammermills, Inc. - "Bull Dog"
- Pennsylvania Crusher Corp.
- Stedman Foundry and Machine Co., Inc.
- Williams Patent Crusher and Pulverizer Co., Inc. - "Fragmentizer"

SHREDDER, Screenings, sewage
- Gruendler Crusher and Pulverizer Co.

SIEVE, Dewatering - Bauer Bros. Co., The - "Hydrasieve"

STERILIZER, Sludge - Dorr-Oliver, Incorporated - "Farrer System"

CLASSIFICATIONS AND DEFINITIONS OF EQUIPMENT AND ACCESSORIES

AFTERBURNER, Gas - These devices, usually gas fired, may be accessories to or integrally incorporated into incinerators. Their purpose is to apply controlled heat to the flue gases after the burning of waste materials, to insure the destruction of odors and the reduction of particulate matter.

ARRESTOR, Spark - Metal or ceramic devices, frequently in the forms of cages, placed over the tops of incinerator stacks to reduce hazards from sparks which might be otherwise emitted.

CHIMNEY - As applied to this report, chimneys are prefabricated sections which can be assembled on the site. They are metal cylinders, lined with high temperature refractory materials.

INCINERATOR - A device for carrying out the process of reducing combustible wastes to inert residue by high-temperature burning. In the context of this report, it also includes those special types of incinerators used for the destruction of laboratory animals, pathological wastes, fumes, gases and liquids by the application of heat. Incinerators are provided with means of using auxiliary fuels to assist in the combustion process.

PYROLYZER - A retort, usually of cylindrical shape, in which wood or other materials are reduced to char by the application of heat in the absence of air and any added moisture. They are sometimes referred to as converters. In addition to the char, combustible gases are also produced. These are used as part of the fuel input to carry on the pyrolyzing process.

SCRUBBER, Gas - Equipment used to remove fly ash or other particulate matter from flue gases of incinerators or other burning devices. They employ sprays of water, wet surfaces and passage of gases through water to accomplish their purposes.

STOKER, Incinerator - Mechanical equipment for the movement and feeding of waste materials through the incinerator burning chamber. They may be of different designs such as alternating or reciprocating, chain grate or variations of these types.

WALL, Refractory - The linings of incinerators which are of refractory brick, tiles or other forms. As applied in this report, they refer to suspended or special air-cooled walls, rather than the firebrick walls commonly laid up as masonry.

OXIDIZER, Air, Wet - A series of equipment components providing a closed pressurized system for the reduction of organic material through oxidation without flame at temperatures of 250°F to 700°F in the presence of water. Low pressure systems nominally operate in a range below 300 psig and temperatures below 350°F. High pressure systems can be operated upwards to 3000 psig in the higher temperature ranges for higher oxidation rates.

PRODUCT LIST
(Type, Manufacturer and Trade Name)

AFTERBURNER, Gas	- Hydro Combustion Corporation	
	- Sargent NCV Division of Zurn Industries, Inc.	
ARRESTOR, Spark	- Sargent NCV Division of Zurn Industries, Inc.	
CHIMNEY	- Power-Pac Stacks, Inc.	
	- Sargent NCV Division of Zurn Industries, Inc.	
INCINERATOR	- Air Preheater Company, Inc.	- "Combustall"
	- American Incinerator Corp.	
	- Brule Incinerators	
	- Calcinator Corporation	- "Calcinators"
	- Combustion Engineering, Inc.	- "Combustopak"
	- Despatch Oven Company	- "Des-Inerator"
	- Garver-Davis, Inc.	- "Destructur"
	- Joseph Goder Incinerators	
	- I.P.C. Industries	
	- Morse Boulger Div. Hagan Industries, Inc.	
	- Nash, Cadmus & Voelker, Inc.	
	- Nichols Engineering & Research Corp.	
	- Plibrico Company	
	- Sargent NCV Division of Zurn Industries, Inc.	
	- Silent Glow Corp.	- "Hydrox-O-Lator"
	- Thermal Research & Engineering Corp.	
	- Vulcan Iron Works, Inc.	
	- Waste Combustion Corporation	- "Consumat"

INCINERATOR, Gas - Garver-Davis, Inc. - "Destructur"
- Thermal Research & Engineering Corp.

INCINERATOR, Liquid
- Garver-Davis, Inc. - "Destructur"
- Hydro Combustion Corporation
- Thermal Research & Engineering Corp.

INCINERATOR, Rotary
- Bartlett-Snow
- Kennedy Van Saun Corporation

INCINERATOR, Slagging
- Dravo Corporation - "FLK"

OXIDIZER, Air, Wet - Zimpro Division
Sterling Drug, Inc.

PYROLYZER - Monsanto Enviro-Chem Systems, Inc.
- Pan American Resources, Inc. - "Lantz Converter"

SCRUBBER, Gas - Chemical Construction Corp.
(Subsidiary of Ebasco Industries, Inc.)
Pollution Control Division - "Chemico"
- M. H. Detrick Co.
- I.P.C. Industries
- Krebs Engineers
- Nichols Engineering & Research Corp.
- Peabody Engineering Corp.
- Research-Cottrell, Inc. - "Incino-Trell"
- Sargent NCV Division
of Zurn Industries, Inc.
- Western Precipitation Division
Joy Manufacturing Co. - "Turbulaire"

STOKER, Incinerator - Detroit Stoker Company
- Flynn and Emrich Company - "Constant-Flo"

STOKER, Incinerator, Chain grate
- Illinois Stoker Company

WALL, Refractory, Suspended
- M. H. Detrick Co.

Aerojet-General Corporation
Environmental Systems Division
9200 East Flair Drive
El Monte, California 91734

Air Preheater Company, Inc.
Subsidiary of Combustion Engineering
Wellsville, New York 14895

Al-Jon, Inc.
P. O. Box 592
Ottumwa, Iowa 52502

Alvey Conveyor Manufacturing Co.
9301 Olive Boulevard
St. Louis, Missouri 63132

American Baler Company, (The)
1000 Hickory Street
Bellevue, Ohio 44811

American Baler Machine Company
Div. National Compactor & Technology
  Systems, Inc.
839 - 39th Street
Brooklyn, New York 11232

American Compressed Steel Corporation
Louisville, Kentucky 40201

American Incinerator Corp.
5710 East Nevada
Detroit, Michigan 48234

American Pulverizer Company
1249 Macklind Avenue
St. Louis, Missouri 63110

Amsco Systems Company
Div. of American Sterilizer Co.
2710 West 21st Street
Erie, Pennsylvania 16512

Anchor Machine Company, Inc.
P. O. Box 260
Jackson, Michigan 49204

Anchor Steel and Conveyor Company
6906 Kingsley Avenue
Dearborn, Michigan 48126

Apex Metal Products
Div. of Hydraulic Refuse Systems Corp.
101 Louise Street
Rochester, New York 14606

Atomic Disposer Corp.
605 East Banning Avenue
Compton, California

Automatic Refuse Systems, Inc.
33201 Harper Avenue
St. Clair Shores, Michigan 48083

Auto Pak Company
4908 Lawrence Street
Bladensburg, Maryland 20710

Autotron, Inc.
3629 North Vermillion
Danville, Illinois 61832

Bal Corporation, William
947 Newark Avenue
Elizabeth, New Jersey 07208

Baldwin Conveyor Co., J. L.
2726 N. Ashland Avenue
Chicago, Illinois 60614

Balemaster Div.
East Chicago Machine Tool Corp.
4801 Railroad Avenue
East Chicago, Indiana

Barrett Electronics Corporation
630 Dundee Road
Northbrook, Illinois 60062

Bartlett-Snow
6200 Harvard Avenue
Cleveland, Ohio 44105

Bauer Bros. Co., (The)
P. O. Box 968
Springfield, Ohio 45501

Bernitz Furnace Appliance Company
301 Old York Road
Jenkintown, Pennsylvania 19046

Black & Decker Mfg. Co.
Towson, Maryland 21204

Black Clawson Company, (The)
Shartle Division
Pandia Division
Middletown, Ohio 45042

Bloomfield/Silex Industries, Inc.
4546 W. 47th Street
Chicago, Illinois 60632

S. Vincen Bowles, Inc.
12039 Branford Street
Sun Valley, California 91352

Bremen Equipment Corp.
3113 So. Gertrude Street
P. O. Box 2656
South Bend, Indiana 46613

Brockway Motor Trucks
Division of Mack Trucks, Inc.
Cortlandt, New York 13045

Brule ("Bru-lay") Incinerators
13920 South Western Avenue
Blue Island, Illinois 60406

Buffalo Hammer Mill Corp.
1245 McKinley Parkway
Buffalo, New York 14218

Bunting Magnetics Co.
9245 Cherry Street
Franklin Park, Illinois 60131

Burtman Iron Works
Readville, Massachusetts 02137

E. W. Buschman Company, (The)
4146 Clifton Avenue
Cincinnati, Ohio 45232

Bus Boy Disposer, Inc.
13150 Saticoy Street
North Hollywood, California 91605

Butler Manufacturing Co.
7400 East 13th Street
Kansas City, Missouri 64126

Bynal Products, Inc.
11990 Franklin Avenue
Franklin Park, Illinois 60131

Calcinator Corporation
P. O. Box 400
Bay City, Michigan 48706

Carman Industries, Inc.
(formerly Carrier Mfg. Co.)
1005 W. Riverside Drive
Jeffersonville, Indiana 47103

Castle Automated Systems
Division of Sybron Corporation
317 Main Street
East Rochester, New York 14445

Also - 1777 East Henrietta Road
Rochester, New York 14623

Central Vac International
3008 E. Olympic Boulevard
Los Angeles, California 90023

Chainveyor Operations
Hewitt-Robins, Inc.
Div. Litton Industries
2041 Davie Avenue
Los Angeles, California 90022

Chemical Construction Corp.
Subsidiary of Ebasco Industries, Inc.
Pollution Control Division
320 Park Avenue
New York, New York 10022

Chilite Plastics, Inc.
2278 Westside Drive
Rochester, New York 14624

City Tank Corporation
Culpeper, Virginia

Clark Equipment Company
Construction Machinery Division
Benton Harbor, Michigan

Cleveland Tramrail Division
of Cleveland Crane & Engineering Div.
of McNeil Corporation
1060 East 289th Street
Wickliffe, Ohio 44092

Columbus McKinnon Corporation
1180 Avenue of the Americas
New York, New York 10036

Combustion Engineering, Inc.
Windsor, Connecticut 06095

Compackager Corporation
2135 Wisconsin Avenue, N.E.
Washington, D.C. 20007

Compaction Equipment Company, Inc.
P. O. Box 2206
Silver Spring, Maryland 20902

Compactor Refuse Handling Systems
900 North 137th Avenue
Seattle, Washington 98133

Comstock Engineering Co.
2311 East Eighth Street
Los Angeles, California

Conco
Material Handling Division
5440 W. St. Charles Road
Berkeley, Illinois 60163

Consolidated Baling Machine Company
Division, N.J. Cavagnaro & Sons.
Machine Corp.
400 Third Avenue
Brooklyn, New York 11215

Construction Products Co., Inc.
Route #7
Brookfield, Connecticut 06804

Container Development Corp.
Watertown, Wisconsin 53094

Converto Mfg. Co.
Div. of Golay & Co., Inc.
Cambridge City, Indiana 47327

Con-Vey International, Inc.
4777 S. E. Sixteenth Avenue
Portland, Oregon 97202

Conveyor Specialties Co.
633 South Palm Avenue
Alhambra, California 91803

Conveyor Systems, Inc.
A. B. Farquhar Div.
6451 Main Street
Morton Grove, Illinois 60053

J. C. Corrigan Co., Inc.
41 Norwood Street
Boston, Massachusetts 02122

County Plastics Corp.
100 Verdi Street
Farmingdale, New York 11735

Currie Machinery Company
1150 Walsh Avenue
Santa Clara, California 95050

Cushman Motors
Lincoln, Nebraska 68501

Cyanamid
Decision Making Systems Dept.
Bound Brook, New Jersey 08805

Dashaveyor Company, (The)
1042 Princeton Drive
Venice, California 90291

Data-Veyors Corporation
3246 Ettie Street
Oakland, California 94608

Delavan Manufacturing Company
811 Fourth Street
West Des Moines, Iowa 50265

Dempster Brothers, Inc.
P. O. Box 3127
Knoxville, Tennessee 37917

Despatch Oven Company
P. O. Box #1320
Minneapolis, Minnesota 55414

M. H. Detrick Co.
20 N. Wacker Drive
Chicago, Illinois 60606

Detroit Stoker Company
Div. of United Industrial Corp.
Monroe, Michigan 48161

Diamond Reo Trucks
Div., White Motor Corp.
Lansing, Michigan 48920

Differential Steel Car Co.
Findlay, Ohio 45840

Dorr-Oliver, Inc.
77 Havemeyer Lane
Stamford, Connecticut 06904

Dravo Corporation
3600 Neville Road
Pittsburgh, Pennsylvania 15225

D-V Metal Fab Co.
(Div. of Data-Veyors Corp.)
3246 Ettie Street
Oakland, California 94608

Eastern Cyclone Industries, Inc.
15 Daniel Road
Fairfield, New Jersey 07006

Ecology Industries, Inc.
433 Liberty Street
P. O. Box 5
Little Ferry, New Jersey 07643

Econo Manufacturing Co.
Celina, Ohio 45822

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245 Woodward Road, S.W.
Albuquerque, New Mexico 87103
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3805 N.W. 36th Street
Oklahoma City, Oklahoma 73112)

Electronic Assistance Corp.
20 Bridge Avenue
Red Bank, New Jersey 07701

Elgin Leach Corporation
222 West Adams Street
Chicago, Illinois 60606

Empire Engineering Co.
385 East Green Street
Pasadena, California 91101

Esco Corporation
1017 Griggs
Danville, Illinois 61832

E-Z Pack Company
(Div. of Hercules Galion Products, Inc.)
P. O. Box 607
Galion, Ohio 44833

Farmer Electric Products Co., Inc.
Tech Circle
Natick, Massachusetts 01760

Fisher-Klosterman, Inc.
2901 Magazine Street
Louisville, Kentucky 40211

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1220 South Acoma Street
Denver, Colorado 80223

Florsheim Manufacturing Company, Inc.
825 No. Lessing Street
Chicago, Illinois 60622

Flo-Tronics
Air Conveyor Div.
1820 Xenium Lane
Minneapolis, Minnesota 55427

Flynn and Emrich Company
3001 Grantley Road
Baltimore, Maryland 21215

FMC Corporation
Hoopeston, Illinois 60942

Riverside Division
3075 - 12th Street (Box 552)
Riverside, California 92505

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Fort Steuben Road
Weirton, West Virginia

Fuller Company
123 Bridge Street
Catasauqua, Pennsylvania 18032

Fusion Rubbermaid Corporation
Statesville, North Carolina 28677

Garver-Davis, Inc.
19200 Villaview Road
Cleveland, Ohio 44119

Gar Wood Industries, Inc.
Wayne, Michigan 48184

General Atronics Corporation
1200 East Mermaid Lane
Philadelphia, Pennsylvania 19118

General Hydraulics of California, Inc.
411 South Flower Street
Burbank, California 91502

Gen Sani-Can Corporation
21 Gear Avenue
Lindenhurst, New York 11757

Gilman Paper Company
Kraft Bag Division (DisPOzit Div.)
Time & Life Building, Rockefeller Center
111 West 50th Street
New York, New York 10020

Goder Incinerators, Joseph
2483 Greenleaf Avenue
Elk Grove Village, Illinois 60007

Gould Products, Inc.
Elmont, Long Island, New York

Grand Aluminum Welding
1232 Commercial Street, N.E.
Salem, Oregon 97301

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2915 No. Market Street
St. Louis, Missouri 63106

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Cedar Rapids, Iowa 52405

Hapman Corporation
630 Gibson Street
Kalamazoo, Michigan 49006

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Industrial Division
440 West National Avenue
Milwaukee, Wisconsin 53246

Heil Co., (The)
3000 W. Montana Street
Milwaukee, Wisconsin 53201

Hercules Galion Products, Inc.
P. O. Box 607
Galion, Ohio 44833

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Div. Litton Industries
Chainveyor Operations
2041 Davie Avenue
Los Angeles, California 90022

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Div., Litton Industries
666 Glenbrook Road
Stamford, Connecticut 06096

Hobart Manufacturing Co., (The)
Troy, Ohio

Hobbs Hyd-Pak
(Div. of Fruehauf Corp.)
Kilpatrick Road
Cleburne, Texas 76031

Hollymatic Corp.
80 North Street
Park Forest, Illinois 60466

Hollywood Plastics, Inc.
4560 Worth Street
Los Angeles, California 90063

Howe Richardson Scale Company
680 Van Houten Avenue
Clifton, New Jersey 07015

S. Howes Co., Inc.
Silver Creek, New York 14136

Hydro Combustion Corporation
9630 Santa Fe Springs Road
Santa Fe Springs, California 90670

Hytrol Conveyor Company, Inc.
St. Louis, Missouri

Illinois Stoker Company
Alton, Illinois 62002

Inca Metal Products Corporation
501 East Purnell Road
Lewisville, Texas 75067

Indiana General
Magnetic Equipment Div.
6001 South General Avenue
Dudahy, Wisconsin 53110

Industrial Bag & Spec., Inc.
1025 Brush
Detroit, Michigan 48226

Industrial Services of America
Tri-Pak Division
P. O. Box 21-070
Louisville, Kentucky 40221

In-Sink-Erator Manufacturing Co.
4700 - 21st Street
Racine, Wisconsin 53406

Insulfab Container Corporation
830 Hayne Street
Spartanburg, So. Carolina 29301

International Harvester Co.
Chicago, Illinois 60611

International Paper Company
Garbax Disposal System
220 East 42nd Street
New York, New York 10017

I.P.C. Industries
687 So. Post Avenue
Detroit, Michigan 48217

Joy Manufacturing Co.
Oliver Building
Pittsburgh, Pennsylvania 15222

Kennedy Van Saun Corporation
Danville, Connecticut 17821

Kiesler Company, Jos. F.
928 West Huron Street
Chicago, Illinois 60622

Kimberly-Clark Corporation
Neenah, Wisconsin 54956

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1111 South 12th Street
Kansas City, Kansas 66105

Kirk & Blum Manufacturing Co., (The)
3120 Forrer Street
Cincinnati, Ohio

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Evansville, Indiana 44704

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400 Heaton Street
Hamilton, Ohio 45011

Krebs Engineers
1205 Chrysler Drive
Menlo Park, California 94025

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Diebold, Incorporated
Lamson Street
Syracuse, New York 13201

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Div. of FMC Corp.
Prudential Plaza
Chicago, Illinois 60601

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Kingsford, Michigan 49802

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3150 West Burleigh Street
Milwaukee, Wisconsin 53245

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305 East 47th Street
New York, New York 10017

McClintock Division
Unarco Industries, Inc.
15005 So. Marquardt Avenue
Santa Fe Springs, California 90670

Malsbary Manufacturing Company
845 - 92nd Avenue
Oakland, California 94603

Marathon Equipment Co., Inc.
1300 Borden Avenue
P. O. Box 160
Leeds, Alabama 35094

Maren Engineering Corporation
16246 School Street
P. O. Box 143
South Holland, Illinois 60473

Mathews Conveyor Company
190 Tenth Street
Ellwood City, Pennsylvania

Maxon Premix Burner Company, Inc.
Muncie, Indiana

M-B Company
1635 Wisconsin Avenue
New Holstein, Wisconsin 53061

Metal Edge Industries
Barrington, New Jersey 08007

Metropolitan Wire Goods Corporation
N. Washington St. & George Avenue
Wilkes-Barre, Pennsylvania 18705

Mid Equipment Corp.
Grundy Center, Iowa 50638

Midland Equipment Division
Midland Truck Caster & Wheel Co.
685 U. S. Highway No. 1
Elizabeth, New Jersey 07207

Miller, Inc., Franklin
36 Meadow Street
East Orange, New Jersey 07017

Mil-Pac Systems
Unit of SFM Corporation
1110 Globe Avenue
Mountainside, New Jersey 07092

Mobil Chemical Co.
Packaging Department
Canandaigua, New York

Molded Fiber Glass Tray Co.
Linesville, Pennsylvania 16424

Mono-Sol Div.
Chris Craft Industries, Inc.
407 County Line Road
Gary, Indiana 46403

Monsanto Enviro-Chem Systems, Inc.
800 North Lindbergh Boulevard
St. Louis, Missouri 63166

Morse Boulger
Div. of Hagan Industries, Inc.
53-09 - 97th Place
Corona, New York 11368

Nash, Cadmus & Voelker, Inc.
70 West Sunrise Highway
Freeport, New York 11520

National Compactor & Technology
Systems, Inc.
839 - 39th Street
Brooklyn, New York 11232

Newark Caster & Truck Corp.
355 Park Avenue
Newark, New Jersey 07107

New London Engineering Company
1700 Division Street
New London, Wisconsin 54961

New York Sani-Can, Inc.
225 Marcus Boulevard
Deer Park, New York 11729

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150 William Street
New York, New York 10038

Olson Division
American Chain & Cable Company, Inc.
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Franklin Park, Illinois 60131

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3690 Santa Fe Avenue
Los Angeles, California 90058

Pak-Mor Manufacturing Company
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P. O. Box 14147
San Antonio, Texas 78214

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Eastern Division
64 Fulton Street
New York, New York 10038

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232 Madison Avenue
New York, New York 10016

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Box 100
Broomal, Pennsylvania 19008

Perfection-Cobey Company
Div. of Harsco Corp.
Galion, Ohio 44833

Phillips Films Co., Inc.
Polyolefin Division
(Subsidiary-Phillips Petroleum Co.)
5570 Creek Road
Cincinnati, Ohio 45242

Piezo Manufacturing Corporation
193 Main Street
Madison, New Jersey 07940

Plibrico Company
1800 N. Kingsbury Street
Chicago, Illinois 60614

Power-Pac Stacks, Inc.
610 Devon Street
Kearny, New Jersey 07032

Prab Conveyors, Inc.
5944 East Kilgore Road
Kalamazoo, Michigan 49003

Qualheim, Inc.
1225 - 14th Street
P. O. Box 368
Racine, Wisconsin 53403

Quickdraft Corporation
1525 Perry Drive, S.W.
Canton, Ohio 44708

Rapistan Incorporated
Rapistan Building
Grand Rapids, Michigan 49505

Refuse Disposal Equipment Co., Inc.
P. O. Box 421
Highland Park, Illinois 60035

Republic Steel Corporation
1315 Albert Street
Youngstown, Ohio 44505

Research-Cottrell, Inc.
Box 750
Bound Brook, New Jersey 08805

Rogers Manufacturing Co., Inc.
220 No. Mahaffie
Olathe, Kansas 66061

Rol-Away Truck Manufacturing Co., Inc.
6143 S.E. Foster Road
Portland, Oregon 97206

Rubbermaid Commercial Products, Inc.
(Subsidiary of Rubbermaid, Inc.)
Winchester, Virginia 22601

Rudolph Poultry Equipment Company
Vineland, New Jersey 08360

St. Regis Paper Company
150 East 42nd Street
New York, New York 10017

Salina Manufacturing Co., Inc.
606 North Front Street
P. O. Box 26
Salina, Kansas 67401

Salvajor Company
4530 East 75th Terrace
Kansas City, Missouri 64132

Sargent NCV Division
of Zum Industries, Inc.
610 Devon Street
Kearny, New Jersey 07032

Screw Conveyor Corporation
700 Hoffman Street
Hammond, Indiana 46320

Seco Electronics Corporation
1001 Second Street, South
Hopkins, Minnesota 55343

Shredmaster Corporation, (The)
891 South Ocean Avenue
Freeport, L.I., New York 11520

Signode Corporation
Strapping Division
2600 N. Western Avenue
Chicago, Illinois 60647

SI Handling Systems, Inc.
P. O. Box 70
Easton, Pennsylvania 18042

Silent Glow Corporation
850 Windsor Street
Hartford, Connecticut 06101

H. E. Smith, Inc.
28880 Southfield Road
Lathrup Village, Michigan 48075

Somat Corporation
Box 831
Coatesville, Pennsylvania 19320

Speaker Sortation Systems Division
Automatic Sprinkler Corp. of America
3250 North 126th Street
Brookfield, Wisconsin 53005

Speedways Conveyors, Inc.
1210 E. Ferry Street
Buffalo, New York 14211

Spencer Turbine Co.
c/o (Rep.) Robson L. Splane
17825 Osborne Street
Northridge, California 91324

Spronz Incinerator Corp.
1262 Plymouth Avenue, South
Rochester, New York 14611

Sprout, Waldron & Company, Inc.
Muncy, Pennsylvania 17756

Standard Conveyor Company
940 Indiana Avenue
North St. Paul, Minnesota 55109

Stedman Foundry and Machine Company, Inc.
Subsidiary-United Engrg. & Foundry Co.
Aurora, Indiana 47001

Sterling Manufacturing Company
241 North Third Street
Laurens, Iowa 50554

Strong-Scott Mfg. Co., (The)
(Berwind Corporation-Process Equip. Group)
451 Taft Street, N.E.
Minneapolis, Minnesota 55413

Sturtevant Mill Company
Park and Clayton Streets
Boston, Massachusetts 02122

Swiftainer Industries Corp.
2345 Hollers Avenue
Bronx, New York 10469

Swimquip, Inc.
3301 Gilman Road
El Monte, California 91732

Syntron
Div. of FMC Corp.
Homer City, Pennsylvania 15748

Tamaker Corp.
P. O. Box 204
Ventura, California 93002

Tampo Manufacturing Company, Inc.
Seal Press Refuse Collection Body Div.
1146 West Laurel Street
P. O. Box 7248
San Antonio, Texas 78207

T&S Equipment Company
Albion, Michigan 49224

Thermal Research & Engineering Corp.
(Subsidiary of Cosmodyne)
Conshohocken, Pennsylvania 19428

Tilt/Load Hoppers
Box 154
Salina, Kansas 67401

Tradewind Industries, Inc.
P. O. Box 96
Liberal, Kansas 67901

Trashmobile Division
Hanna Enterprises
1122 N. Williams Avenue
Portland, Oregon 97227

Truck Equipment Company of Georgia, Inc.
20-24 - 14th Street, N.W.
Atlanta, Georgia 30309

Truck Equipment Corporation
9400 Midlothean Turnpike
Richmond, Virginia 23235

Tubar Waste Systems
Div. of Uhrden, Inc.
Sugarcreek, Ohio 44681

Union Camp Corporation
233 Broadway
New York, New York 10007

Uniroyal, Incorporated
Div. of United States Rubber Company
2638 North Pulaski Road
Chicago, Illinois 60639

Universal Handling Equipment Co.
100 Burland Crescent
Hamilton, Ontario
Canada

Vac-U-Max
227 Main Street
Belleville, New Jersey 07109

Vacuum Can Company
19 South Hoyne Avenue
Chicago, Illinois 60612

Val-Jac Manufacturing Co., Inc.
5650 North Broadway
Wichita, Kansas 67219

Versa Cart Containers
P. O. Box 142
Northbrook, Illinois 60062

Versa Corporation
P. O. Box 152
Mt. Sterling, Ohio 43143

Vibra Screw, Incorporated
755 Union Boulevard
Totowa, New Jersey 07512

Vulcan Iron Works, Inc.
Wilkes-Barre, Pennsylvania

Wascon Systems, Inc.
Subsidiary - Robins & Myers
210 Bonair Avenue
Hatboro, Pennsylvania 19040

Waste Combustion Corporation
P. O. Box 6295
Richmond, Virginia 23230

Waste King Universal
3300 East 50th Street
Los Angeles, California 90058

Waterbury Hydraulics Industries, Inc.
58 Lafayette Street
Waterbury, Connecticut 06708

Wayne Engineering Corporation
1st & Iowa Streets
Cedar Falls, Iowa 50613

Wayne Manufacturing Co.
1201 East Lexington Street
Pomona, California 91766

Wear-Ever Aluminum, Inc.
5th Avenue & 11th Street
New Kensington, Pennsylvania

Webb Company, Jervis B.
9000 Alpine Avenue
Detroit, Michigan 48204

Western Body & Hoist Company
8901 Juniper Street
Los Angeles, California 90002

West Virginia Pulp and Paper Company
30 Park Avenue
New York, New York 10017

Wilkinson Chutes, Inc.
619 East Tallmadge Avenue
Akron, Ohio 44310

Williams Patent Crusher and Pulverizer
Co., Inc.
2701 North Broadway
St. Louis, Missouri 63102

W-W Grinder Corporation (The)
2957 North Market
Wichita, Kansas 67219

Zimpro Division of
Sterling Drug, Inc.
Rothschild, Wisconsin 54474

Zink Company, John
4401 South Peoria
Tulsa, Oklahoma 74105

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